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Via Satellite

October 1998

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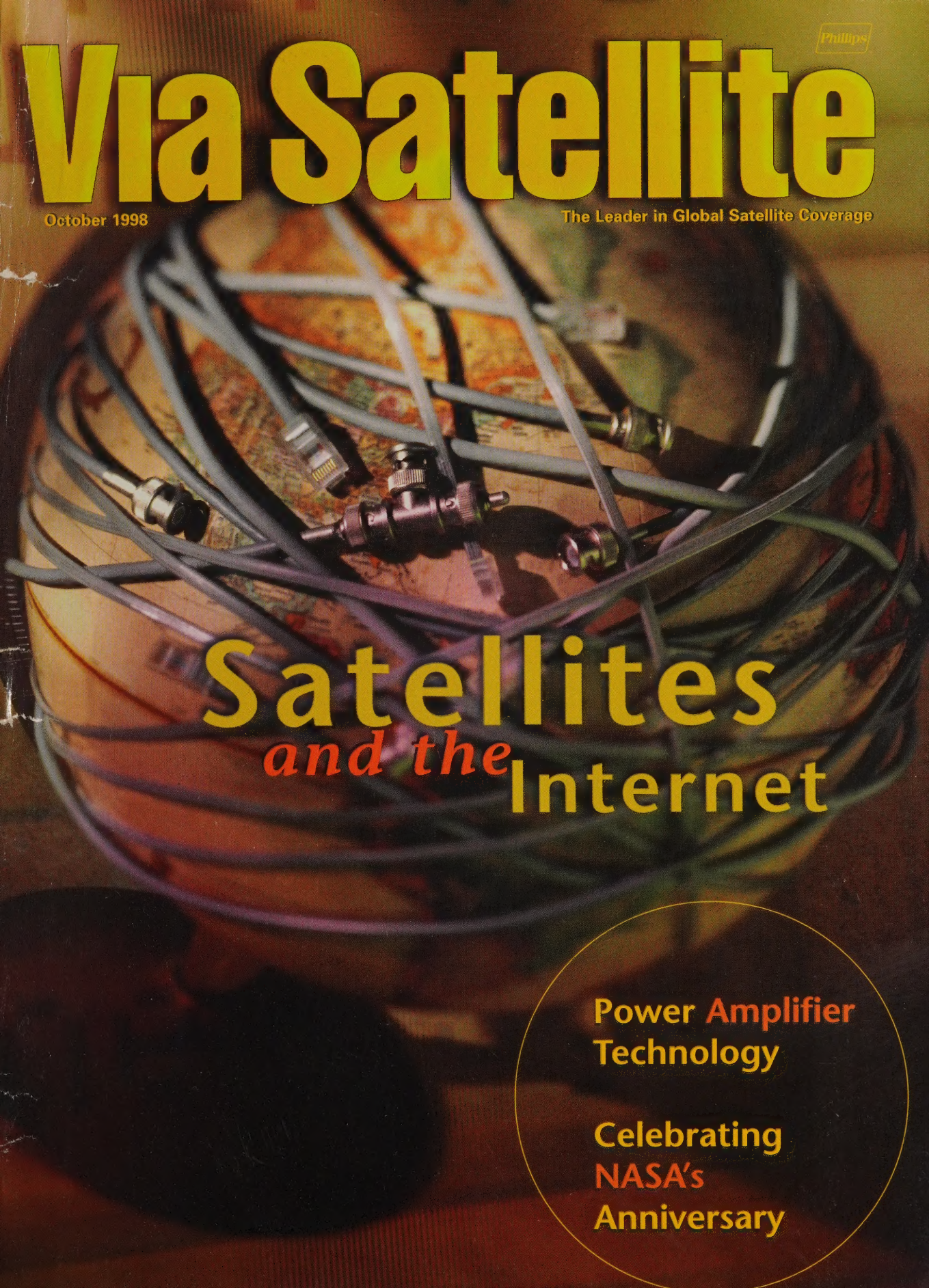


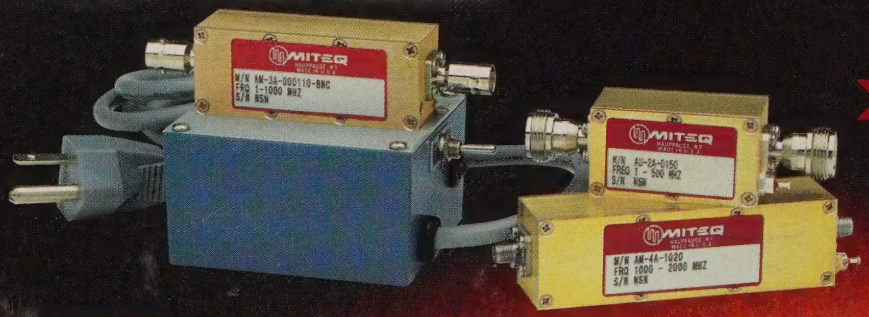
Satellites and the Internet

Power Amplifier Technology

Celebrating NASA's Anniversary

SATCOM IF AMPLIFIERS

70 AND 140 MHz



3 YEAR WARRANTY

FEATURES

- Flat amplitude response, less than ±0.1 dB
- Low VSWR, typically 1.3:1
- Linear group delay, typically 0.5 ns p-p
- Shipment from stock to two weeks

OPTIONS

- Integrated AC power supply 85–265 VAC, 47–440 Hz
- 50 and 75 ohm models
- BNC or N connectors
- Impedance (in/out) 50/75 ohms
- Impedance (in/out) 75/50 ohms

MODEL NUMBER	FREQUENCY (MHz)	GAIN (dB, Min.)	FLATNESS (± dB, Max.)	NOISE FIGURE (dB, Max.)	OUTPUT POWER (dBm, Min.)	VSWR IN/OUT (Max.)
70 MHz AMPLIFIERS • 50 OHM IMPEDANCE (IN/OUT)						
AU-1510-70	50–90	13	0.20	7.0	23	1.5:1
AU-1049-70	50–90	14	0.20	2.7	10	1.5:1
AU-1046-70	50–90	19	0.20	2.5	10	1.5:1
AU-1499-70	50–90	21	0.20	8.0	17	1.5:1
AU-1006-70	50–90	30	0.20	1.3	8	1.5:1
AU-1158-70	50–90	30	0.20	2.9	20	1.5:1
AU-1263-70	50–90	43	0.20	1.5	20	1.5:1
AU-1027-70	50–90	45	0.20	1.4	10	1.5:1
AU-1204-70	50–90	52	0.20	2.0	20	1.5:1
70 MHz AMPLIFIERS • 75 OHM IMPEDANCE (IN/OUT)						
AU-1149-70	50–90	15	0.25	5.0	20	1.5:1
AU-1127-70	50–90	29	0.20	1.3	7	1.5:1
AU-1138-70	50–90	29	0.20	3.0	20	1.5:1
AU-1360-70	50–90	45	0.20	2.0	20	1.5:1
140 MHz AMPLIFIERS • 50 OHM IMPEDANCE (IN/OUT)						
AU-1372-140	100–180	7	0.20	8.0	13	1.5:1
AU-1538-140	100–180	13	0.20	7.0	17	1.5:1
AU-1049-140	100–180	14	0.20	2.7	10	1.5:1
AU-1046-140	100–180	19	0.20	2.7	10	1.5:1
AU-1006-140	100–180	30	0.20	1.3	8	1.5:1
AU-1158-140	100–180	30	0.20	2.9	19	1.5:1
AU-1263-140	100–180	43	0.20	1.5	19	1.5:1
AU-1027-140	100–180	45	0.20	1.4	10	1.5:1
AU-1204-140	100–180	52	0.20	2.0	19	1.5:1
140 MHz AMPLIFIERS • 75 OHM IMPEDANCE (IN/OUT)						
AU-1127-140	100–180	29	0.20	1.3	7	1.5:1
AU-1293-140	100–180	29	0.20	1.5	7	1.5:1
AU-1092-140	100–180	29	0.20	3.2	19	1.5:1
AU-1360-140	100–180	45	0.20	2.0	19	1.5:1

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- 50 ohm IF impedance

UPCONVERTERS

Output Frequency (GHz)	Model Number
28 – 29.1	U-9458
29 – 30.25	U-9458-1
30 – 31	U-9458-2
27.5 – 31	U-9458-3

DOWNCONVERTERS

Input Frequency (GHz)	Model Number
17.7 – 18.8	D-9413
18.8 – 19.3	D-9413-1
19.2 – 20.2	D-9413-2
20 – 21.2	D-9413-3
17.7 – 21.2	D-9413-4

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REGULATORY REVIEW 14
Spectrum Management, Auctions and More

One of the biggest—if not the biggest—regulatory issues facing the satellite industry is availability of spectrum. Increasingly, the issue of spectrum availability is being tied to "economic criteria," which usually means charges for the rights to use radio frequencies. Studies and reports abound on this issue, including the report authorized by the ITU Radiocommunication Assembly and prepared by Radiocommunication Study Group 1 last year on "Economic aspects of spectrum management."—*Gerald E. Oberst*

COVER STORY

IP-OVER-SATELLITE: A GLOBAL SOLUTION NOW 16
Satellites and the Internet

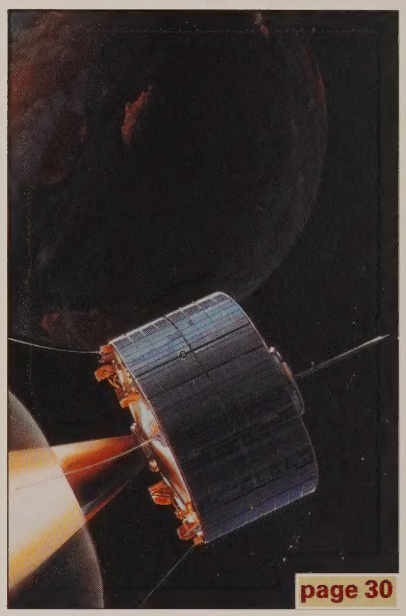
The Internet is very hot, but Internet Protocol (IP)-over-satellite is probably even hotter as global demand is heating up rapidly for instant access to the mighty and unmatched stream of U.S.-based Internet content. GEO satellite operators and IP-over-satellite service providers are addressing this situation now. Internet service providers (ISPs) outside the United States have generated a significant demand for these more specialized satellite services, and this demand shows no sign of subsiding.—*Peter J. Brown*

NASA AT 40 30
The Early Years Pay Off

Communications via satellite. Many say it was the brightest commercial jewel in the whole treasure chest. Of all the scientific and technological marvels from the first four decades of the National Aeronautics and Space Administration (NASA), which celebrates its 40th anniversary this month, nothing else is so commercially precious. —*Robert N. Wold*

EARTH STATION HIGH POWER AMPLIFIERS: KPA, TWTA OR SSPA? 46
Choosing an Amplifier

The high power amplifier (HPA) in an earth station facility provides the RF carrier with power to the input terminals of the antenna that, when combined with the antenna gain, yields the equivalent isotropic radiated power required for the uplink to the satellite. Choosing one is highly dependent on its application, the cost of installation and long-term operation and many other factors. This article will summarize the technologies, describe their important characteristics and identify some issues important to understanding their differences and relative merits.—*Robert A. Nelson*



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About the cover: This month, *Via Satellite* revisits the runaway growth of the IP-over-satellite market and how it is connecting even the remotest regions to the resources of the Internet. Cover design by Rhonda Scharlat. Images copyright © 1998 Photodisc, Inc.

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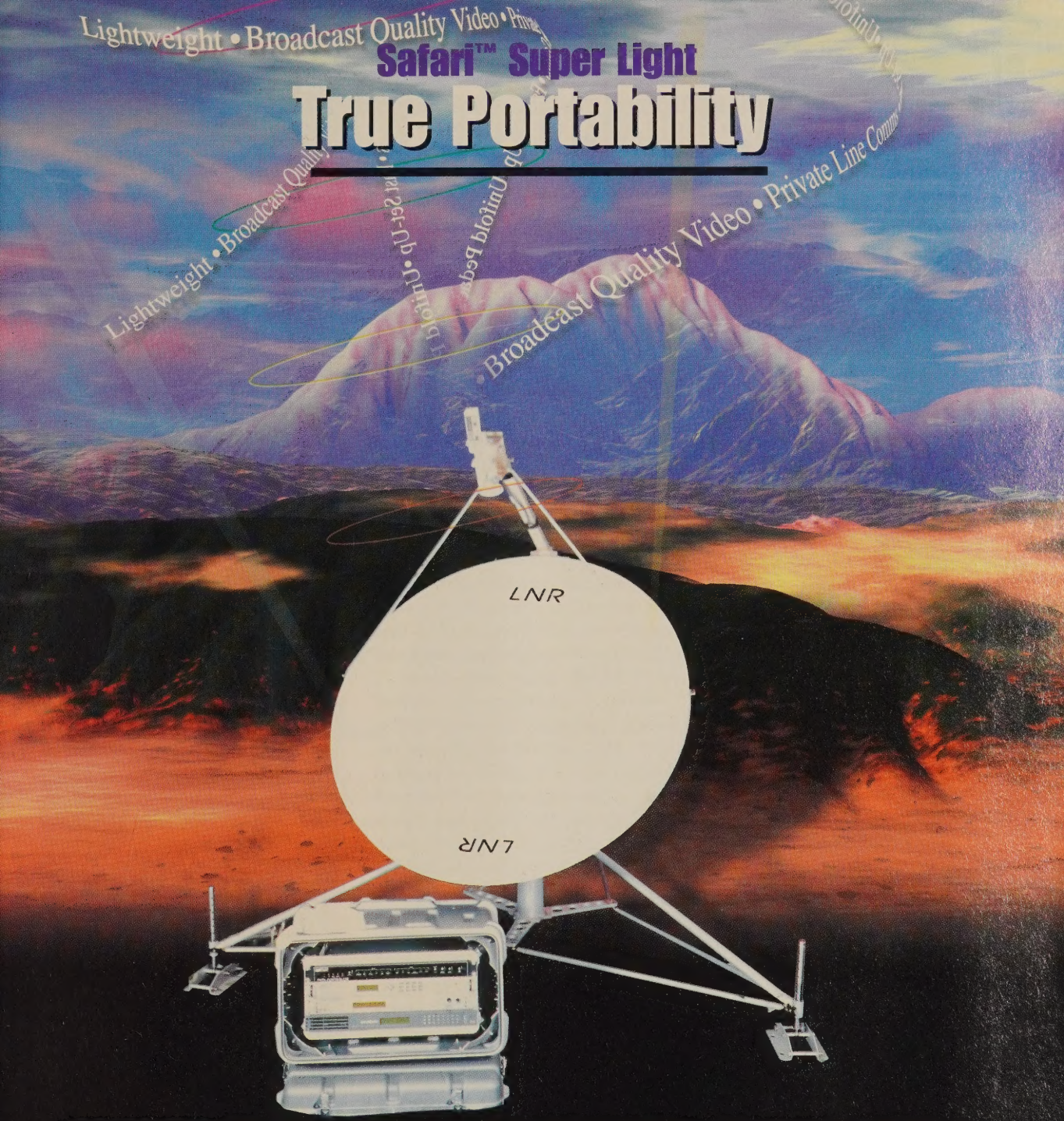

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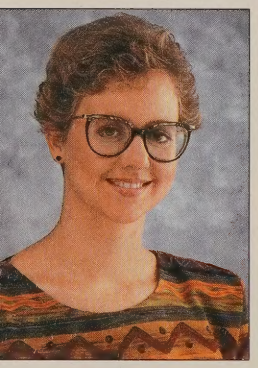
Editor's Insight

NASA at 40—Congratulations from the Satellite Industry



This month, the aerospace industry celebrates the 40th anniversary of the creation of the National Aeronautics and Space Administration (NASA).

Many people worldwide know NASA best for its manned space missions to the moon and, more recently, its numerous Shuttle flights. NASA's contributions to the commercial satellite industry, however, are equally great, although perhaps less recognized than their stature would suggest.

In fact, as Bob Wold describes in this month's issue, NASA is responsible for the development of many of the most important communications satellite technologies, beginning in 1960 and continuing to the present day. In its early years, NASA promoted the development of manned spaceflight, as well as weather and navigational satellites.

Initially, NASA focused on the development of "passive" satellites, which merely bounce signals off of reflectors. For example, Echo 1, a gigantic balloon from which radio signals were reflected back to earth, demonstrated the feasibility of radio transmission via satellite, measured propagation characteristics, and demonstrated the effectiveness of various transmitting, receiving, coding and modulation equipment.

NASA also promoted the development of an "active" satellite, which could receive, amplify and retransmit signals back to earth. Under a NASA program in 1962, for example, an RCA-built satellite, Relay 1, was used to transmit television and provide international, wireless telephone links.

In one of the industry's most stunning milestones, a NASA program led to the launch of the world's first geostationary satellite in 1964, making Arthur C. Clarke's vision of a spacecraft orbiting at 22,300 miles above the earth's equator a reality. The third Syncom satellite, built by Hughes, became the first satellite to reach geostationary orbit, and demonstrated the viability of this orbit to provide 24-hour-a-day coverage over a fixed area of earth, thus eliminating the expensive and complicated need to track the satellite on the ground.

In 1966, NASA oversaw the launch of the first Applications Technology Satellite (ATS). This program encompassed the launch of three ATS satellites on behalf of NASA. These spacecraft demonstrated many important technologies and applications, including frequency division multiple access and distance learning, to name but a few.

In 1993, NASA launched the Advanced Communications Technology Satellite, built by Lockheed Martin, which has played a seminal role in satellite technology development. This Ka-band satellite features onboard switching, and has been an important prototype for many companies in the satellite industry who plan to use this higher frequency for two-way, high-bandwidth on-demand services.

This month, NASA celebrates four decades of development. The commercial satellite industry owes a great deal to this illustrious organization. I hope you'll join me in congratulating NASA for the important contributions it has made to the satellite market over the years.

Cynthia Boeke

Cynthia Boeke
Editor/Publisher

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For The Record

HS 601 Review Complete
Lockheed Martin Ventures
Sea Launch Suffers Setback

RECENT LAUNCHES AND CONTRACTS

❖ ARIANESPACE

Arianespace successfully launched **ST 1**, the first telecommunications satellite operated by Chunghwa Telecom of Taiwan and Singapore Telecom, on August 25. The launch was carried out within the scope of a contract with Matra Marconi Space, who built and designed the satellite, which weighed 7,161 pounds at liftoff.

ST 1 is equipped with 16 Ku-band and 14 C-band transponders and will cover an area extending from the Middle East to the Far East, from its orbital position over the Indian Ocean at 88°E. The satellite's expected lifetime is 12 years.

❖ CHINA GREAT WALL

Two more **Iridium** satellites were successfully launched on August 19 on board a Chinese Long March 2C/SD rocket from the Taiyuan Satellite Launch Center in China. This 16th successful launch for Iridium in the last 15 months brings the total number of operational satellites on orbit to 67.

This launch was part of the deployment phase and replaces two previously launched satellites located in the same orbital plane that experienced anomalies. One of the replacements fills an operational slot in the constellation; the other serves as a spare for that plane. The satellites are part of Iridium LLC's 66-satellite global wireless personal communications network, which is designed to offer voice, data, fax and paging services with a handheld telephone and pager.

❖ HUGHES

Hughes Space and Communications Co. has delayed the launch of the **UHF F9** communications satellite to replace an electronic part in the communications payload and conduct additional testing.

The satellite was scheduled for launch from Cape Canaveral Air Station, FL, on September 15. A new launch date has been set for October 19. This issue is unrelated to the spacecraft control processor anomalies on three in-orbit HS 601 satellites.

The HS 601 model satellite had successfully completed most of its testing. However, during an inspection at the Hughes factory in Los Angeles, it was determined that the workmanship on the installation of a capacitor in the communications payload did not meet Hughes' standards. The capacitor is being replaced as a conservative measure to ensure full mission life success, and the rework time will delay the launch.

Hughes has also postponed the launch of the **JCSAT 6** satellite because of complications with two electronic units during pre-launch testing. Investigation is under way, and a power surge caused by lightning during a thunderstorm near the satellite processing facility is a likely cause. No new launch date has been set.

The satellite was in Florida being prepared for a mid-August launch from Cape Canaveral. Hughes engineers and technicians were conducting routine pre-launch tests, and both telemetry encoding units (TEUs) on the satellite and some test equipment began performing erratically. The test equipment was returned to Hughes, and the TEUs will be removed from the satellite and examined to determine if they can be repaired.

❖LOCKHEED MARTIN

Lockheed Martin Global Telecommunications and GE Americom formed a joint venture to deploy a new satellite system, **GE 1A**, which will provide a

TIN-PLATED RELAY SWITCHES BLAMED FOR THREE HUGHES PROCESSOR MISHAPS

Hughes Electronics Corp. announced in early August that its HS 601 communications satellite is ready to launch again after an extensive investigation of recent spacecraft control processor (SCP) failures pinned the cause on tin-plated relay switches.

Because there appears to be no need to further alter the construction of the 601-model birds, it was decided as of presstime that the launch of the Panamsat Corp. Galaxy 10 and the Société Européenne des Satellites' Astra 2A satellites would proceed as scheduled.

The 601-model satellites, manufactured by Panamsat's sister company Hughes Space and Communications, are among the most widely used satellite types in the world. Thirty-six of them remain in orbit, but one of them is the Panamsat Galaxy 4 that suffered a problem with its backup processor that rendered the satellite useless. An anomaly with the Galaxy 4's primary processor stemmed from a different, isolated incident.

DBS 1 and Galaxy 7 had primary SCP failures, but services have been maintained with onboard backup processors. A team of Hughes engineers and outside experts confirmed that all three troubled satellites suffered electrical shorts with their processors.

The most probable cause was pinpointed as a tin-plated latching relay that serves as an on/off switch within the SCP. Under certain conditions, a tiny, crystalline structure—less than the width of a human hair—can grow and become a bridge between the terminal and the relay case. Those occurrences can cause an electrical short. But to occur, pure tin must be present, a protective coating must leave part of the tin exposed and the system's relay case must be grounded.

As a precaution against future satellite failures, the Hughes Electronics board of directors voted on August 10 to expand the

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RECENT LAUNCHES AND CONTRACTS

wide range of services, including television distribution and wideband Internet applications to businesses and consumers in the Asia Pacific. The new satellite will have 28 Ku-band transponders and is scheduled to launch in July 1999. It will be located at 97°E. Its expected life is 15 years.

❖MATRA MARCONI

Eutelsat has signed a contract with Matra Marconi Space for a new satellite called **Ressat** in order to guarantee service continuity in the event of a launch failure of one of the units in its W series, the first of which will go into orbit in October this year.

The new satellite will be delivered in December 1999, and will have basic characteristics that will enable Eutelsat to satisfy operational requirements at 7°E, 10°E, 16°E and 36°E. Equipped with 28 transponders and based on the Hot Bird spacecraft platform, it will operate in the fixed-satellite services band and provide one fixed widebeam over Europe, North Africa and the Middle East and one steerable beam.

❖ PANAMSAT

Galaxy 10, a Hughes-built HS 601 HP spacecraft with 24 C-band and 24 Ku-band transponders, was destroyed during a Delta 3 rocket failure at Cape Canaveral, FL.

Galaxy 10 was to provide video and telecommunications services throughout the United States. The satellite and launch were fully insured. Boeing Co., which provides Delta launch services, announced that an investigation into the cause of the Delta 3 failure would begin immediately.

❖ U.S. AIR FORCE

A **Titan 4A** rocket, carrying a top-secret satellite for the U.S. Air Force, exploded after liftoff on August 12 from Cape Canaveral. The rocket cleared the launch pad, but incurred an undetermined problem that turned the rocket and payload, worth more than $1 billion, into falling debris.

satellite fleets of its DirecTV and Panamsat subsidiaries. DirecTV will replace its DBS 1 satellite, while Panamsat will modify two satellites under construction and procure four additional birds. Those additional satellites are expected to be launched in the latter half of 1999.

The two new satellites will be a Galaxy 4 replacement and an international satellite. The ground spares will allow expedited launches to occur if backup capacity or expanded services are needed. Panamsat is reviewing proposals from satellite suppliers and completing a financial analysis of its plan. Hughes is considered the frontrunner to win the contract.

LOCKHEED MARTIN FORMS NEW UNIT

Lockheed Martin Corp. is moving to broaden its scope and provide comprehensive global telecommunications solutions with two moves in August that are aimed at enhancing its competitiveness.

Lockheed Martin Global Telecommunications was created to combine several existing joint ventures and other business operations under a single management team that will focus on dramatically growing the company's global network services. The goal is to gain a bigger slice of the world's estimated $50 billion global network services revenue pie.

There also is the potential to capture a proportionately larger chunk of the market when it grows to annual revenues of $120 billion by 2002, said John Sponyoe, who will head Lockheed Martin Global Telecommunications.

Part of the formula involves deepening involvement in the satellite services market by taking a 50 percent interest in the Asia-Pacific satellite system that GE American Communications is developing. The system will be served by a new spacecraft, the GE 1A, which will use a Lockheed Martin A2100 bus.

Tim Logue, a Washington-based satellite and telecommunications consultant with Coudert Brothers law firm, said Lockheed Martin's investment in the Asia Pacific program as an equal partner with GE Americom strengthens the program.

The joint venture will fall under the umbrella of Lockheed Martin Global Telecommunications. Satellite sales, launch services and on-orbit deliveries will continue to be managed by Lockheed Martin Space and Strategic Missiles Sector.

Other units that will be partly operated within the expanded telecommunications unit are Lockheed Martin Intersputnik, Astrolink, Lockheed Martin Telecommunications, the commercial communications systems of Lockheed Martin Management and Data Systems and the commercial communications elements of Lockheed Martin Western Development Laboratories.

SEA LAUNCH POSTPONEMENT

Boeing Co. is attempting to develop new procedures for sharing information with its Russian and Ukrainian Sea Launch partners after the State Department recently ordered the company to stop the collaboration following Boeing's admission that its employees violated U.S. disclosure rules numerous times.

The State Department ordered Boeing to suspend working with its partners on the launch program due to concerns that Boeing sent sensitive technical information to the Russian and Ukrainian companies.

Sea Launch, an international joint venture involving Boeing, RSC-Energia of Moscow, Norway's Kvaerner and KB Yuzhnoye/PO Yuzhmash of the Ukraine, is slated to hold its inaugural launch early next year.

"We have been suspended by the State Department from working with our Russian and Ukrainian partners until we have the proper procedures in place to protect against the transfer of sensitive technical information," said Tim Dolan, a Boeing spokesman. Boeing officials are hopeful the suspension of operations with its partners will be short-lived; no delay of the first launch is planned.

Investigators with Congress and the U.S. Justice Department have been looking into whether Boeing and other U.S. companies have violated federal laws by disclosing sensitive technology to China. A number of hearings already have been held in the House and Senate to address those concerns. Boeing previously had not been a target of those inquiries, which focused on Loral Space and Communications Inc. and Hughes Space and Communications.

Boeing executives now must complete detailed written answers to questions by State Department officials about the technical information given to Boeing's foreign partners, sources said. Boeing officials also must offer a plan to prevent future security lapses.

MISSION: To design a new generation launch vehicle that will dramatically reduce the cost and complexity of going into orbit. This will enable private companies to launch countless space-based businesses, creating a new universe of opportunities in the century ahead - just as private enterprise helped the aviation industry take off during *this* century.

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Reader Response 10

CALENDAR

OCTOBER

1-2 American-European Satellite Communications Seminar, Paris (+33/1-43-12-29-80; fax: +33/1-43-12-21-72)

12-14 Inter-union Satellite Operations Group Tripartite Meeting, Sydney (416/598-9877, x15, fax: 416/598-9774, e-mail: nanba@tvo.org)

26-28 Telecon 17, Anaheim, CA (800/815-3400; fax: 925/513-4255; Web: www.abctelecon.com)

28-30 Naval Symposium: Commercial Collaboration on Space, Huntsville, AL (fax: 540/653-6118; e-mail: aboyd@navspace.com)

NOVEMBER

2-4 Fourth Ka-Band Utilization Conference, Venice (215/497-2009 or +39/010-2722-383; Web: http://kronos.lerc.nasa.gov/ka/ka_uc.htm)

1-3 Third European Workshop on Mobile/Personal Satcoms, Venice (+39/010-2722383; fax: +39/010-2722183, e-mail: iic.istcomge@interbusiness.it)

4-6 Asia-Pacific Satellite Communications Council Conference, Seoul (+82/2-508-4884; fax: +82/2-568-8593; e-mail: apscc@chollian.dacom.co.kr; Web: www.apscc.or.kr)

9-10 Introduction to Satellite Technology, Washington, DC (800/777-5006 or 301/424-3338; fax: 301/309-3847)

16 Satellite Basics, Houston, TX (800/777-5006 or 301/424-3338; fax: 301/309-3847)

17-18 PetroSat 98: The Future of Global Oil and Gas Communications, Houston, TX (800/777-5006 or 301/424-3338; fax: 301/309-3847)

FEBRUARY

2 Satellite Finance and Investment Summit, Washington, DC (800/777-5006 or 301/424-3338; fax: 301/309-3847)

3-5 Satellite 99—Dawn of a New Era, Washington, DC, (800/777-5006 or 301/424-3338; fax: 301/309-3847; Web: www.phillips.com/satellite)

WHO READS VIA?

Photo courtesy of Bob Wold.

Satellite pioneer Dr. Harold A. Rosen follows the progress of the industry he helped to create by reading the latest issue of Via Satellite.

Circle Reader Response 35

Via Satellite

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VS1098
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October 1998 Issue

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4	26	48	70	92	114	136	158	180	202	224	246
5	27	49	71	93	115	137	159	181	203	225	247
6	28	50	72	94	116	138	160	182	204	226	248
7	29	51	73	95	117	139	161	183	205	227	249
8	30	52	74	96	118	140	162	184	206	228	250
9	31	53	75	97	119	141	163	185	207	229	251
10	32	54	76	98	120	142	164	186	208	230	252
11	33	55	77	99	121	143	165	187	209	231	253
12	34	56	78	100	122	144	166	188	210	232	254
13	35	57	79	101	123	145	167	189	211	233	255
14	36	58	80	102	124	146	168	190	212	234	256
15	37	59	81	103	125	147	169	191	213	235	257
16	38	60	82	104	126	148	170	192	214	236	258
17	39	61	83	105	127	149	171	193	215	237	259
18	40	62	84	106	128	150	172	194	216	238	260
19	41	63	85	107	129	151	173	195	217	239	261
20	42	64	86	108	130	152	174	196	218	240	262
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- ❑ 05. Petroleum Retailer
- ❑ 06. Retailer
- ❑ 07. Transportation
- ❑ 08. University/School
- ❑ 09. End Users (Corporate/Commercial/Industrial)

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- ❑ 35. Insurance
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- ❑ 37. Investor

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- ❑ 51. Video Transmission

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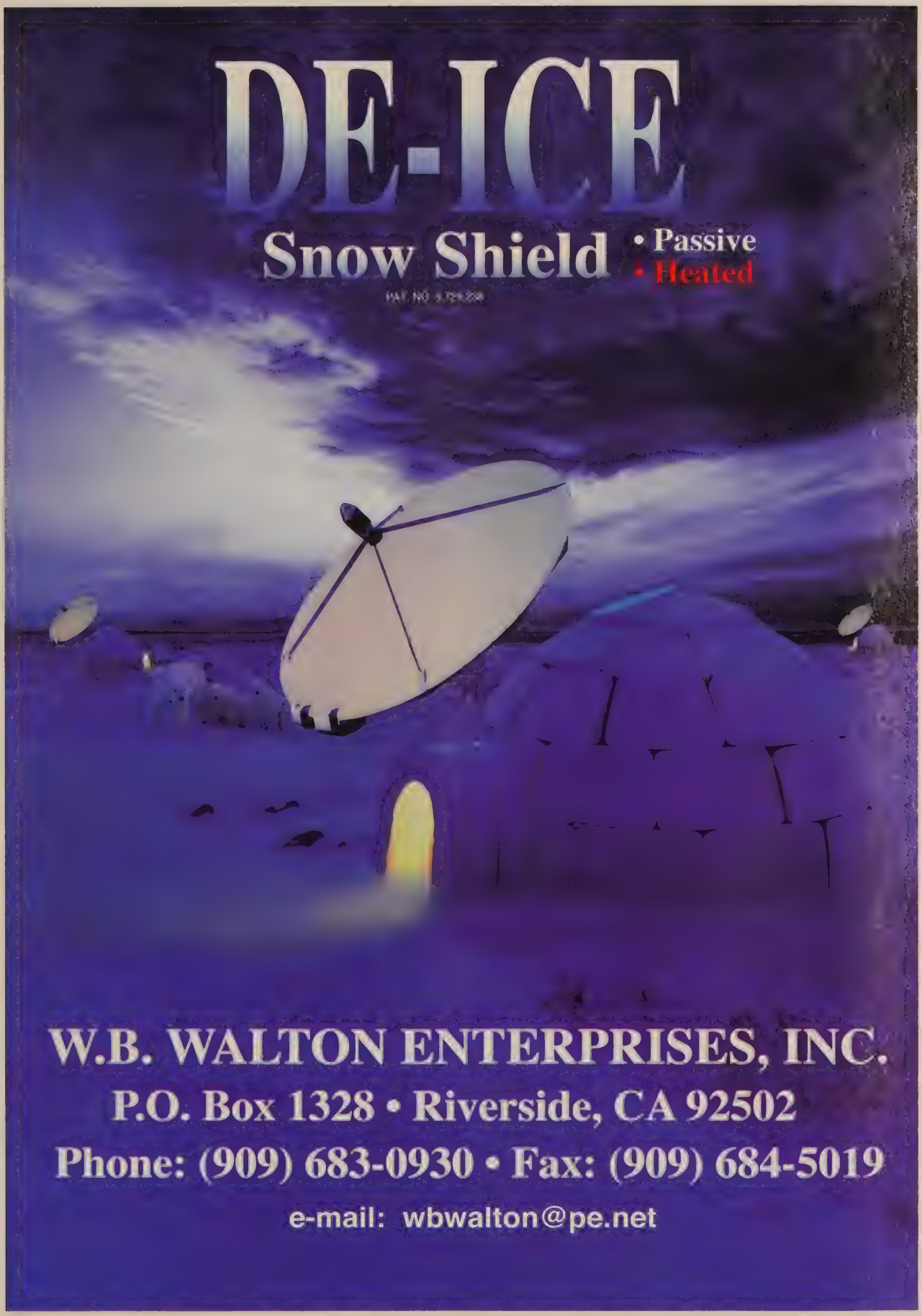
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Reader Response 12

Regulatory Review

Spectrum Management, Auctions and More

by Gerald E. Oberst Jr.

One of the biggest—if not the biggest—regulatory issues facing the satellite industry is availability of spectrum. Increasingly, the issue of spectrum availability is being tied to "economic criteria," which usually means charges for the rights to use radio frequencies.

The number of reports, studies and other papers on spectrum management is enormous. A starting point for analyzing the issues on an international level is the report authorized by the ITU Radiocommunication Assembly and prepared by Radiocommunication Study Group 1 last year on "Economic aspects of spectrum management." The 70-page report was published in October 1997 after two years of work in the study group.

The main purpose of the report is to describe for developing countries how to organize and finance national spectrum management systems. In doing so, the report analyzes spectrum assignment methods, including auctions, licensing fees and transferable property rights in spectrum. It assesses the benefits of using the radio spectrum and describes country experiences with various methods.

Along the way, the report has language useful to the satellite industry. In describing auction procedures to allocate spectrum, the report acknowledges that auctions may be "inefficient or impractical for certain services or situations." A prime example is global or regional satellite systems.

The report states that if auctions for such systems were held in multiple countries, the resulting cumbersome process could lead to "delays in implementing new and innovative services." This is the problem often identified by the satellite industry, which complains that sequential auctions would make it virtually impossible to plan rationally or implement a global or regional system.

The same point comes up in the report's description of extensive U.S. experience with auctions. It notes that the FCC held a "very limited" auction for domestic Direct Broadcast Satellite (DBS) service licenses, and the FCC at the time said the service was different from many other satellite services because its footprint fell exclusively within the United States.

The United Kingdom has been extremely active in the theory and practice of economic criteria for licensing radiocommunication services, and earlier this year amended its Wireless Telegraphy Act to allow auctions and other pricing schemes for allocating licenses. It is no surprise that U.K. regulators have been very involved in follow-on efforts to the ITU study.

Thus, the United Kingdom led the effort to submit a lengthy paper in July 1998 to the same ITU Study Group that prepared the earlier report. The new paper describes European work relating to economic aspects of spectrum management. It states that rising demand for spectrum in Europe has led to new approaches to spectrum management. Countries increasingly are using economic criteria in Europe to improve their spectrum management, according to the U.K. paper.

Again, however, the U.K. paper reiterates the problem of auctions for satellite systems. It acknowledges the ITU report position and also the views of industry that "pan-national" satellite coverage makes auctions inappropriate.

This approach is consistent with U.K. policy. Earlier this year the U.K. Radiocommunications Agency (RA) asked for comments on the idea of auctioning a U.K. DBS orbital position. The RA carefully noted that the slot was for national service only, not for international coverage. When the U.K. Department of Trade and Industry discussed how to apply increased spectrum charges in a 1997 Spectrum Management White Paper, it also avoided new charges for the satellite industry. The department said the response to increased charges in the U.K. could simply be for the industry to move its earth stations elsewhere in Europe.

The satellite industry cannot expect to get a free ride. If other important elements of the communications industry face new or higher spectrum charges, then satellite companies will soon face similar costs. Nevertheless, the U.S. Satellite Industry Association (SIA) last year set forth cogent arguments why satellite auctions are a bad idea. Among the association's points was the problem of sequential auctions—because satellite footprints cover many countries, it could be virtually impossible for an operator to acquire rights in each country in an economically efficient manner.

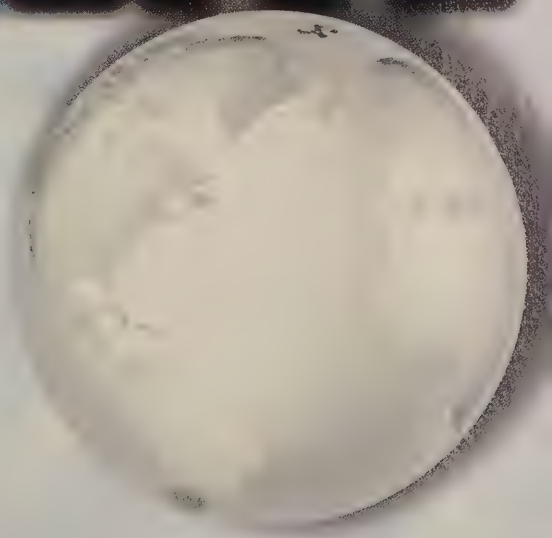
The satellite industry already is implementing some of the most spectrum-efficient technology, but that technology is heavily capital intensive, and high spectrum fees could seriously impede the new services the industry provides. Moreover, according to the SIA, high national fees in one country merely encourage operators to go to other countries for authorizations (an argument the United Kingdom already has recognized).

With ITU study groups constantly looking at these issues and sending advice to developing countries, it pays for the satellite industry to stay vigilant. For instance, India last year proposed to adopt auctions for satellite broadcast facilities, and Brazil currently is auctioning orbital rights. "Economic criteria" might mean spectrum efficiency to economists, but it could mean high costs and new barriers to the satellite industry.

Gerry Oberst is an attorney in the Brussels office of the Hogan & Hartson LLP law firm. He can be reached by fax at +32/2-505-0996 or e-mail at geo@hhlaw.com.

INTERNET + SATELLITE

IT IS THE WORLD-WIDE WEB ISN'T IT?



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A global solution now

by Peter J. Brown

"The IP-over-satellite market today consists of leased transponders for bent-pipe interconnection of Internet backbone switching points with satellite Internet service operators and a small number of direct-to-consumer Internet services, such as DirecPC and Astra-Net in Europe. Combined, these market segments total approximately $178 million in revenues to satellite system operators," says Scott Clavenna, a senior analyst at Pioneer Consulting in Cambridge, MA. "Because the largest share of this market consists of wholesale bandwidth leases from providers, such as Intelsat, Panamsat and Orion, only estimates are possible because these suppliers do not clearly track what their leased capacity is used for."

Clavenna predicts that this market will grow to $2 billion in annual revenue by 2002, and that Ka-band satellite systems will propel the IP-over-satellite market to $30 billion by the year 2007.

As you will see in a moment, the IP-over-satellite sector is energized and brimming with bandwidth.

IP-Over-Satellite

THE INTERNET IS VERY HOT, BUT INTERNET PROTOCOL (IP)-OVER-SATELLITE IS PROBABLY EVEN HOTTER AS GLOBAL DEMAND IS HEATING UP RAPIDLY FOR INSTANT ACCESS TO THE MIGHTY AND UNMATCHED STREAM OF U.S.-BASED INTERNET CONTENT. GEO SATELLITE OPERATORS, AND IP-OVER-SATELLITE SERVICE PROVIDERS, ARE ADDRESSING THIS SITUATION NOW. INTERNET SERVICE PROVIDERS (ISPs) OUTSIDE THE UNITED STATES HAVE GENERATED A SIGNIFICANT DEMAND FOR THESE MORE SPECIALIZED SATELLITE SERVICES, AND THIS DEMAND SHOWS NO SIGN OF SUBSIDING.

SSI MICRO: IT WORKS...END OF STORY

Anyone who thinks that IP-over-satellite is an unproven technology or that it is a high-tech option that will emerge sometime in the future needs to talk to Jeff Philipp, president and CEO of SSI Micro in Fort Providence, Northwest Territories, Canada. Philipp operates the largest ISP in the Northwest Territories. For the past two years, SSI Micro has been delivering IP feeds to many remote locations in northern Canada and recently started to construct its own private frame relay satellite network. Philipp sees IP over satellite as a timely solution today.

"IP over satellite is not the issue. It works...end of story. The issue is what kind of data service do you need for your application. If you have huge distances to cover and satellite is the only solution available, then it can be done well," Philipp says. "If you live in a remote region where analog voice is delivered over satellite anyway, then going to a digital IP service even for voice over satellite is not going to be noticeable.

"IP as a communications medium is highly valued and while maybe not as essential as food and water, it is very important to many people in the North. The huge uptake of Internet and e-mail is a good indication of how valued it is," Philipp adds.

One example is the village of Iqaluit on Baffin Island, the designated capital of the new Canadian province of Nunavut, which spans much of the central and eastern Canadian Arctic. Out of a total population of approximately 4,200 people—2,500 Inuit and 1,700 non-native inhabitants—Philipp reports that 25 percent of the Iqaluit's population is now online.

SSI Micro uses Telesat Canada's Anik E1 satellite and provides a satellite frame relay feed into Iqaluit. For Cambridge Bay and four other smaller communities in the Kitikmeot region, SSI Micro installed a private frame relay Ku-band satellite network in the last six months. This network is designed around ACT Communications equipment using a shared outbound transmission and independent return paths to the hub. The remote earth stations are using 2.4-meter antennas with 10 W transmitters and ACT frame relay gear. Philipp indicates that cost savings as well as the ability to draw from a mix of newer technologies is what propels SSI Micro to install its own satellite networks. He is currently in the final planning stages of a new 12-site, $1.5-plus-million satellite network expansion.

"This new network is much larger in scale and bandwidth. The design has multiple transmit hubs, which are all C-band this time for better high Arctic coverage. Each site includes anywhere from two to 10 demodulators to make up a full mesh network with speeds up to 2 Mbps," Philipp says.

Philipp sees the alternatives as cost prohibitive. A 56 kbps leased line costs approximately $2,500 per month, while a frame relay link with only an 8 kbps committed information rate (CIR) costs approximately $2,650 per month, according to Philipp.

"Today, I find our company involved in projects ranging from incorporating a simple corporate SQL database into a Web site to designing frame relay satellite networks for delivering voice and data to some very remote locations. IP technology is behind most of our day-to-day business, and the workload and opportunities are increasing daily," Philipp says.

ORION: SOARING DEMAND FOR WORLDCAST

While numbers alone do not tell the whole story, nevertheless the 1998 numbers from Loral Orion Inc. in Rockville, MD, indicate that Orion is right on track when it comes to IP-over-satellite. According to Carl Wu, Orion's director of Internet products, Orion offers its Worldcast service customers both capacity leasing and infrastructure. In turn, these customers will drive Orion's IP-related revenues to $15 million by the end of this year, up from $3 million last year.

"Our bookings are actually running far higher than our revenue. We see ourselves

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in the NSP or network service provider sector, not the ISP sector," Wu says. "We intend to establish peering relationships with other network providers, not try to compete with them."

Wu describes Orion's current peering agreements with UUnet, Frontier's Globalcenter and Apex Global Information Services Inc. (AGIS), which is 20 percent owned by Qwest Communications, as indicative of Orion's strategy to grow its ground segment in step with its increased space assets. Orion has a redundant ATM link between its Dulles Corridor POP (point of presence) in Virginia and its uplink in Mount Jackson, VA. Orion also uses Cisco routers and Ascend Communications ATM and frame relay switches.

With twenty-eight 54-MHz and six 36-MHz Ku-band transponders, including three serving only IP-based traffic, Orion 1 has been in service over the North Atlantic at 37.5°W since 1995. Orion 1 will be joined by Orion 2 in mid-1999 at 12°W. Orion 3 will be launched later this year into a slot at 139°E over the Pacific. Orion 3 will feature a mix of Ku-band and C-band transponders that are designed primarily to achieve optimal levels of service throughout the rain-intensive monsoon season in Southeast Asia.

At the same time, Orion's teleport will be operational on the island of Oahu in Hawaii. This new facility includes a fiber link to the United States via the new Southern Cross (TPC-5) undersea cable, which will ultimately expand the undersea link between the United States and Australia.

"We can achieve an effective throughput on an Orion 1 transponder of approximately 45 Mbps; however, once we shift to a DVB (Digital Video Broadcast) platform in November, our goal is to increase to 58 Mbps," Wu says. "DVB offers other functional benefits besides higher efficiency utilization of our transponders. Among other things we will be able to lower our capital costs and enable customers to receive high-speed data streams using Ethernet or Fast Ethernet."

Wu describes a three-phase rollout of DVB beginning in late 1998. Conditional access-driven IRDs—essential for sustaining virtual private networks—will appear in early 1999, and then a full multicast capability will become available.

"We are increasing our market share, while beefing up our value-added services as we go after the content market." Wu says. "Our burstable services can go from 512 kbps up to 2 or 4 Mbps. By peering with different ISPs, we have further enhanced the robustness of our network.

"We're not just a pass-through agent. We offer 24x7 network management. We know link utilization and traffic patterns. We can look at how heavy the traffic is and where the packets are dropping off," Wu says. "With this proactive monitoring capability, we can execute dynamic routing changes to ease congestion while advising our customers how to better tailor their own networks to handle any new trends or patterns that we have detected."

AGCAST: A BLENDING OF DBS AND IP

The Agcast Network in West Des Moines, IA, is a service of the Data Broadcasting Corp. in Jackson, WY. Since 1996, Agcast has combined an agricultural data information service available on the Internet with the Echostar high-power, Ku-band DBS service.

Using transponder 14 on Echostar 1 at 119°W, Agcast broadcasts at 19.2 kbps and 57.6 kbps to approximately 3,500 customers nationwide, according to Mark Gorman, Agcast's vice president of network engineering. Agcast subscribers use a small high-speed adapter module built by Baldwin Electronics, which connects their PC to an Echostar 4000 or 5000 DVB IRD. An Agcast customer does not need to be hooked up to the Internet.

"We went with a hybrid DBS data feed and a land-based Internet link because we did not want to be tied to a single mode of delivery. We take 128 kbps off a single transponder, but it is not a fixed allocation. We ride on the transponder's remnant bandwidth after the audio and video have been

ORBCOMM: E-Mail On the Go

Dulles, VA-based Orbcomm Global L.P. (Orbcomm) is up and running. As the first operational LEO constellation, Orbcomm offers an e-mail service component in addition to its utility monitoring, fleet and mobile asset management and remote site monitoring services. With Iridium launching in a voice-only mode with no fixed date for any data services, Orbcomm has the immediate lead product on the LEO side.

According to Scott L. Webster, Orbcomm's chairman and CEO, Orbcomm's existing fleet of 20 satellites is able to offer service 70 percent of the time with full, 24-hour-a-day coverage projected by the end of this year. Webster makes it very clear that Orbcomm's e-mail capability is focused on short, high-value messages. Webster projects that 30 percent of Orbcomm's traffic will involve personal messaging.

The Magellan GSC 100 hand-held global satellite communicator makes global e-mail access possible, subject to approval. The GSC 100 sells for approximately $999, according to Webster. Its specification sheet lists an outbound data rate of 4800 bps and an inbound data rate of 2400 bps with a maximum message of 2000 bytes.

Orbcomm's satellites operate in concert with gateway earth stations. When an earth station is not in view, the satellites operate in a "store and forward" or so-called "Globalgram" mode, which allows a maximum message size of 200 characters. Each GSC 100 is equipped with its own e-mail address—@orbcomm.net.

While the GSC 100 is billed as an easy way to obtain global service, Magellan literature spells out the fact that Orbcomm customers must be aware of where they are operating, and that each country must have its own licensee for Orbcomm services in place before any ORBCOMM services—e-mail or whatever—are initiated. Customers need to verify with Orbcomm whether or not the GSC 100 can be used in a particular country, according to an Orbcomm spokesperson. A list of these countries is maintained on Orbcomm's Web site at www.orbcomm.com. Today, Orbcomm services are fully authorized in the United States, Canada, Japan and Malaysia as well all ocean areas. At the same time, 11 other countries have granted Orbcomm temporary authority.

allocated. This can total as much as 700 kbps. Our application separates the display and the data delivery functions into multiple layers," Gorman says. "This permits multiple delivery options. The Internet push and satellite delivery modules are interchangeable, and they can even run simultaneously.

"We didn't want to set up two separate infrastructures for two distinct classes of customer, IP and satellite. So, on the interactive back channel side, all customers are viewed as Internet customers, while on the outbound path, everyone is viewed as satellite customers," Gorman says. "If a customer has TCP/IP and an ISP, we automatically establish a back channel into Agcast via the customer's ISP. If a customer does not have Internet access, a virtual TCP/IP connection into Agcast is created with the customer's modem."

Gorman points out that Agcast has the ability to synchronize the whole path to the Echostar uplink center—Echostar's DBS uplink facility is located in Cheyenne, WY—offline, establishing a block so everything queues up, rather than spilling out over the wire.

"A lot of our service hinges on the practical limit of the serial port on the customer's PC," Gorman says. "Why low speed? We surveyed our customers as far as their in-home hardware was concerned, and we found that with a low-speed format, we had the ability to reach at least 85 percent of our potential customer base. We wanted to keep things simple and relatively inexpensive. We did not want our customers having to open the PC. It is completely external, and it works well for us."

Photo courtesy of Teleglobe.

Teleglobe's Des Laurentides teleport in Canada.

Gorman indicates that Agcast is looking at the Adaptec PCI card, along with a much higher potential data delivery speed in the range of 30 Mbps.

"Echostar wants fully integrated video and data, and they are using a custom engineered version of the Adaptec card. We wanted to launch and gain valuable experience, pushing and managing data through the satellite and pushing data through the Internet simultaneously," Gorman says. "We are truly married to the Internet, including our satellite-only delivery. Our application is browser-based, it responds to forms, data is queued up, and we have an established back channel for live Internet sessions. This puts us in a unique position to leverage simultaneous video and Internet applications for both urban as well as rural customers.

"We do multicasting. We can narrow or profile down the broadcast into highly segmented groups or even single individuals," Gorman says. "We can dynamically shift the broadcast both on satellite or via the interactive back channel."

Photo courtesy of Panamsat.

Panamsat's earth station facilities in Homestead, FL.

GLOBECOMM SYSTEMS: STEPPING INTO THE IP SERVICES SECTOR

Globecomm Systems Inc., in Hauppauge, NY, recently formed an alliance with Germantown, MD-based Hughes Network Systems (HNS) called Netsat Express Inc. HNS leads the global VSAT market. With $59 million in revenues last year, Globecomm is, among other things, the world's second largest supplier of gateway-type headends after NEC, according to Euroconsult Research and Gary C. Gomes, executive vice president at Netsat Express.

"Over the past two years we have initiated service covering Eastern Europe, Russia and the Caribbean. We have customers, including ISPs in these regions, as well as universities and businesses. Our market is institutional users, rather than consumers," Gomes says. "We have made a significant investment in developing service offerings for our customers, including our PC Vector based on DirecPC technology from HNS, and our Access Plus services based on technology from Globecomm's and Netsat Express' own developments."

According to Mike Gorsuch, assistant vice president of HNS' satellite networks division for North America, today's high bandwidth VSAT systems offer a compelling communications option for emerging bandwidth-hungry applications.

"HNS' VSAT technology is faster and less expensive than traditional terrestrial solutions, and the DirecPC Enterprise Edition is the only system that currently offers high-speed channel rates of up to 24 Mbps. Traditional T-1 lines, on the other hand, can cost several times more while offering channel rates of only 1.5 Mbps," Gorsuch says.

"A single high-speed 24 Mbps carrier can also offer a scalable and economical path to support future application growth," he continues. "Candidate business applications include the delivery of MPEG video and data files via IP multicast as well as traditional two-way TCP/IP data sessions for LAN internetworking."

"The *raison d'etre* for Netsat Express is to *segue* Globecomm into the services end of the industry and to bring Globecomm into the IP realm at the same time. Globecomm has always been heavily involved in integrated digital voice/data networks, which use packet-based technologies and have a traditional focus on carriers," Gomes says. "We are placing a strong emphasis on voice-over-IP, on CIR-based solutions in the 2 Mbps range in particular, on caching, on data accelerators and on the development of reliable delivery techniques, using software-based approaches without direct error acknowledgement, for example."

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Interpacket Group: C-Band Is the Way to Go

The rapid proliferation of small dedicated Ku-band VSATs used for all forms of data traffic has left many people with the impression that Ku-band is the transmission frequency standard for the emerging GEO satellite-based, IP-over-satellite sector.

C-band is the preferred delivery mechanism for The Interpacket Group Inc. in Santa Monica, CA, which offers a mix of Internet services under the Espresso banner. They use C-band transponders on Solidaridad 1, PAS 2, PAS 3 and PAS 4, and they see it as a more reliable approach.

"We've encountered too many reliability problems on Ku-band. Right now, we're using Ku-band into Northeast Asia and the reliability is not acceptable for data transmission," says Jon Mansey, Interpacket's chief science officer. "Not only is C-band a bit cheaper, but it gives us more flexibility. We can take a 36 MHz transponder on Solidaridad 1, for example, and split it up into a 4x8 Megabit, plus a 3x2 Megabit carrier configuration. Using 8 Mbps is a handy measure. We can feed sixty-four 48 kbps customers through a single 8 Mbps carrier."

With DS-3 (45 Mbps), POP facilities in New York City and Los Angeles linked to the UUnet backbone via Cisco routers, as well as another POP in London fed by a transatlantic DS-3 feed from New York, Interpacket can offer its Espresso service at speeds up to 45 Mbps. However, Interpacket sees most of the demand for its flat rate-based CIR services between 128 kbps and 2 Mbps with burstability up to 8 Mbps.

"This burstability comes into play all the time as an option. All of our customers understand that everything above CIR is free bandwidth," Mansey says. "One thing we emphasize is that we do not oversell bandwidth. We keep it at a 1:1 ratio as far as U.S. backbone bandwidth is concerned. We also eliminate router hops."

As for the TCP/IP delay and congestion issue, Interpacket finds that no such problem exists.

"We are using TCP/IP in its raw form. You might say that we are living with the delay. The satellite hop adds 250 milli-seconds (ms) to the roundtrip time, and what we find is that the further you are from the United States, the less the additional delay is noticeable," Mansey says. "We see ping times of 550 ms to Africa and South America via our satellites, which are considerably less than the terrestrial route."

Interpacket uses San Diego-based Starguide Digital Networks' IRDs. The Starguide IRDs are easy to install and it has helped to reduce Interpacket's customer equipment costs from $5,000 to $3,500, according to Mansey. In May, Interpacket added a bandwidth management system with class-based queuing (CBQ) to its overall network control. This system offers a frame relay-like networking structure, and this allows Interpacket to closely monitor and control all bandwidth sharing and bandwidth allocation over multiple satellite circuits and downlinks.

Netsat Express operates the Long Island International Teleport. It is concentrating on broadcast applications of IP with multicast as a subset of broadcast to implement new services, such as webcasting and caching and what Gomes describes as persistent connection-based services.

In early 1998, Globecomm launched the Netsat Express Access Plus Enterprise, which provides shared-bandwidth connections to and from the Internet. Operating in a broadcast mode, this new service uses class-based queuing (CBQ) traffic management to allow for the dynamic sharing of the bandwidth among sites while maintaining fixed minimum CIRs for each site. Gomes describes it as ideally suited to address "the bursty nature of Internet usage."

"Yahoo can reach every ISP in the world on a daily basis with as few as three satellites," Gomes says. "And yet at the same time, look at all the aggregate data you can move in a month at a continuous download speed of just 2 to 4 kbps. If you do the math, you will discover that just 1 kbps transmitted for one month amounts to 324 megabytes of information, and one transponder can support about 60 Mbps or 60,000 kbps."

MENTAT: TCP NOT OPTIMIZED FOR SATELLITE FEEDS

IP-over-satellite's chief advantage is that it can deliver large bandwidths to areas either unserved or underserved by terrestrial fiber. At the same time, IP-over-satellite is subject to a number of adverse conditions that can have a detrimental impact on effective throughput rates and satellite network efficiency. Bit error rates, congestion, queue management, Window size and buffer status can all have a serious impact on the overall IP-over-satellite performance curve.

Another potential source of problems is the asymmetry encountered in back channel bandwidth, which in many IP-over-satellite systems is only a fraction of the forward channel bandwidth. Because the Transmission Control Protocol (TCP) emerged well in advance of any detailed discussions of IP-over-satellite, TCP often gets mistakenly identified as the source of the problem, when in fact, it is the operating environment and not TCP alone that is the source of the problem. The design of TCP is not optimized for conditions encountered during satellite transmissions.

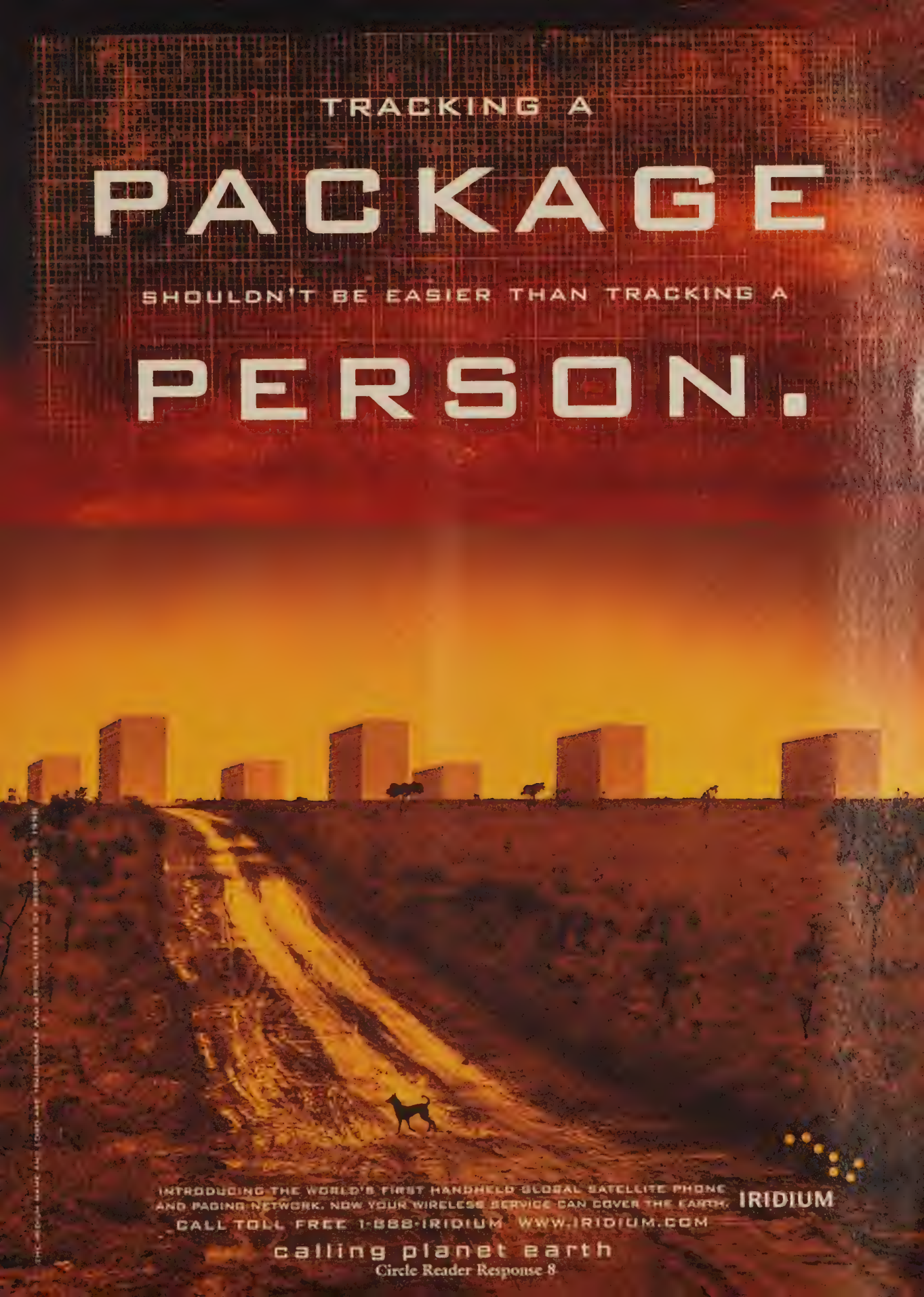
One result is that the standard GEO satellite hop out 22,300 miles and back can create problems by itself with the inherent transmission-related delay breaking down the flow of packets between the send and receive sites, especially at very high transmission speeds. These speeds are what draws everyone to the GEO IP-over-satellite option. Although some IP-over-Internet players seem prepared to live with the delay, Mentat Inc. in Los Angeles believes that Mentat's Skyxpress (Skyx) Gateway System can provide superior performance than TCP, even TCP with selective acknowledgement (SACK).

"TCP works well as a general purpose protocol for a congested environment, such as the Internet; however, TCP perceives a satellite delay and bit errors as congestion and conservatively decides to slow down as a result," says Jerry Toporek, Mentat's vice president of engineering.

"We want to get the throughput speeds over the satellites up to what the system is capable of and achieve the highest throughput rate possible. At the same time, Skyx needs to remain transparent to end users and clients," Toporek says.

"Skyx does not change how TCP works over the terrestrial portion of the connection, nor does it break TCP's end-to-end semantics unlike spoofing solutions, which artificially inject acknowledgements into the TCP stream in order to attempt to speed up data delivery," says DC Palter, Mentat's vice president for sales and marketing.

Throughput is the focus here. For its Skyx Gateway System, Mentat asserts that average throughput, on a simulated forward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link speed of 10 Mbps with a reverse link speed of 128 kbps (using the standard Webstones http performance benchmark), with 50 clients active, amounts to 7.7 Mbps via Skyx and only 2.7 Mbps on TCP/IP. This performance enhancement is especially noticeable with larger file sizes, according to Palter. A 5 MB file requires a download time of 15.3 seconds using Skyx versus 337.5 seconds for TCP/IP. In the case of 500 KB file, the Skyx delivery time is 2.2 seconds as opposed to 36.1 seconds for TCP/IP.

Mentat has NASA test results to back up its claims. These tests were conducted at NASA's High Performance Computing and Communications Group, which is based at the Goddard Space Flight Center in Greenbelt, MD.

FANTASTIC: A BIG FAN OF IP

When Deutsche Telekom AG announced last summer that it was spending $48 million to buy a 20-percent stake in Israel-based Vocaltec Communications Ltd.—one of the largest global players in the voice-over-IP market—it was clear that Deutsche Telekom could see the future of telecommunications. In April, Deutsche Telekom announced that, through its venture capital group known as T-Venture, it was taking an undisclosed equity stake in The Fantastic Corp., and that it was licensing The Fantastic Corp.'s Channel Management Center software for broadband multimedia distribution.

In a nutshell, Swiss-U.S. The Fantastic Corp. is classified as an enabler, a company that provides a fuel source for the IP-over-satellite engine. With approximately 130 employees in offices in Zug and Lugano, Switzerland, New York City, London and Singapore, Fantastic is developing IP-based software tools for media aggregation and distribution. This includes server and broadcast-ready browser software known as Mediasurfer. For the European market, Fantastic also has standardized on DVB.

Fantastic is pursuing a broadband strategy that extends well beyond the satellite realm. One such concept is what Fantastic calls the focused affinity network (FAN), which defines clusters of end users who value frequently-updated, multimedia-enriched content.

"For now, we are not likely to see lots of video streaming on corporate LANs. MIS managers will resist allowing MPEG 1 quality video on their networks. Why? Because the video would eat up bandwidth and overwhelm the system. So, any application that might diminish the productivity of the LAN will have to be truly unbelievable," says John A. Yapaola, Fantastic's vice president of sales and marketing for the Americas. "Our model fits well with what you might call an Extranet. It doesn't compete with the Internet, rather it can be viewed as a complementary enhancement to the Internet."

Yapaola indicates that Fantastic is in active talks with potential partners, and he goes so far as to hint at the fact that an announcement regarding a strategic relationship with a major U.S.-based satellite player could happen soon.

"A major problem is the issue of standards in multicasting. It is still so new, and companies in this space are lobbying to get their transport protocol selected as the standard. Certain IP multicast companies tried to push their transport protocol and it would have meant a closed environment. That is not our model. We're saying that the

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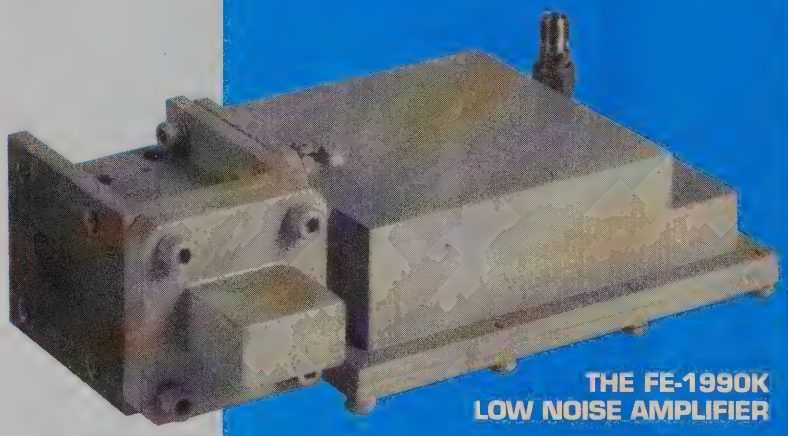

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Photo courtesy of Panamsat.

Panamsat has developed a sophisticated Internet satellite service that allows customers to switch circuit speeds to meet their individual demands.

transport standard should be open and if something emerges, that's great for the entire industry," Yapaola says. "Our delivery platform will work concurrently with the IP multicast standards that develop."

PANAMSAT: FROM SPOTBYTES TO SPOTBEAMS

Robert A. Bednarek, chief technology officer at Panamsat Corp. in Greenwich, CT, is constantly reminding people that 80 percent of the total Internet content resides in the United States, and that Internet users overseas are eager to have access to that content. Panamsat's Spotbytes service is designed to meet this growing demand. Panamsat uses PAS 2, PAS 3, PAS 5 and soon PAS 8 to service its ISP customer base.

According to Bednarek, IP-over-satellite traffic represents Panamsat's fastest growing sector. He projects a 300 percent growth rate in IP traffic for 1998. However, this fast-growing category represents just 3 to 4 percent of Panamsat's total satellite-based traffic.

"Two years ago, the maximum circuit that was needed on any of our satellites was a T1 (1.5 Mbps). Today, 1 to 4 Mbps is common, and 20 to 45 Mbps (DS-3) is not uncommon. Reducing packet transit times is a key goal," Bednarek says. "We are doing a considerable amount of trunking or providing DS-3 service between routers for ISPs. We have one 27 MHz Ku-band satellite transponder right now doing nothing but providing IP traffic to ISPs in Australia.

"The key feature of the satellite is the ability to change circuit speeds. You can start at 128 or 258 kbps and double it, and double it again if necessary. All we have to do is partition the switch to meet the increased traffic," Bednarek says. "In the IP model, the speed limit is still set by the final modem speed. The true peak transfer speed for a single IP address talking to another single IP address is 384 kbps," he says.

Because congestion—the "World Wide Wait"—is a major issue for ISPs, Spotbytes is designed for instant upspeeding. Bednarek describes it as a flexible, fully bundled service that can be scaled progressively to meet any ISP's changing requirements. ISPs seeking a feed into the U.S. backbone can tap into Panamsat's two primary earth stations in Homestead, FL, and Napa, CA, which are equipped with ATM switches.

"With cable modems coming into the mix, and with corporate LANs and WANs adapting to the new IP services beyond simply e-mail and including digital video, files are becoming much bigger and more sophisticated," Bednarek says. "What is perhaps the most important technological development is the dramatic reduction in the cost of storage. This new, vastly less-expensive and expanded storage capacity is enabling more and more multicasting to take place. At the same time, linear programming is not the only staple any more."

THE OBSTACLES REMAIN

The IP-over-satellite industry as a whole still has some obstacles to overcome. Just consider two samples of the e-mail feedback *Via Satellite* got when we asked for input on IP-over-satellite.

"Company X isn't into satellite links yet. Too expensive, too much delay for interactive conferencing, which is our core business," says one high-tech company executive whose identity will remain anonymous.

"The major problem is that it will remain a niche targeted at people in hard to reach locations," says Paul Van Keep, who started a new Internet software company last year known as Sumatra Software in Wassenaar, the Netherlands. "Satellite bandwidth will never be able to compete with land-based connections. Now that ADSL is coming, and people are starting to get addicted to T-1 speeds in their home, they will not accept a 'slow' 64 kbps Internet hookup anymore. The old adage of software development, 'All programs expand to fill available memory,' holds true for the Internet as well: 'All data transfer expands to fill available bandwidth.'

"For totally wireless Internet connectivity to catch on, we will need a number of improvements in a lot of fields. I do not see it happening in the next couple of years. IPv6 is needed to support an explosion in the number of Internet devices. Bandwidth improvements are needed for wireless devices and to support the migration to IP of all communications, including TV, cell phones, etc.," Van Keep continues.

More solutions are on the way. In late 1997, Panamsat announced its plans for a new digital satellite service known as V-Stream. This 12-satellite GEO constellation is designed to meet future demand using high-powered spotbeams tapping the V-band (50/40 GHz). It is scheduled to begin service in the early 21st century.

TELEGLOBE: FIBER INBOUND, SATELLITE OUTBOUND

McLean, VA-based Teleglobe Communications Corp. is the world's second largest owner of undersea fiber-optic-based cable systems. It operates three satellite earth stations in Canada. It holds a 35 percent stake in Orbcomm. And Teleglobe is definitely in the spotlight as far as IP-over-satellite is concerned, with 50 countries connected to its backbone via satellite under the Globeinternet banner.

Teleglobe announced in late July that it is preparing to push the envelope in terms of multicast-based services and caching capabilities via satellite in a joint beta test with Intelsat of "push" technology developed by A&T Systems in Silver Spring, MD. This test will get underway in November.

"One of the things we have done with Embratel in Brazil is to use the Intelsat 805 satellite at 304.5°E to establish a hybrid, asymmetrical Internet access connection with a 34 Mbps simplex (satellite receive-only) link. A second 34 Mbps simplex connection will be up in August. Routing is via cable inbound to the United States and a satellite return path," says Bob Bernstein, director of Globeinternet product management at Teleglobe.

"Brazil is awaiting the completion of the final construction phase of the Americas 2 undersea cable, and the current shortage of such cable capacity has created a surge in demand for satellite.

"When large ISPs order a connection, it is not a situation where the link is going to become bursty," he continues. "ISPs fill it to the brim, not on the inbound (to the United States) path, but on the return path. We find that traffic for these ISPs is highly aggregated with a smooth traffic profile and exhibits a peak period of eight to nine hours on average. All this traffic is asymmetric in nature, and ISPs can meet their projections for additional demand by just adding satellite capacity."

Bernstein describes a similar situation in Australia—and in the rest of the Asia-Pacific region for that matter. In Australia, where Teleglobe is working with Telstra, the trans-Pacific undersea fiber-optic cable known as Southern Cross is awaited.

"These hybrid connections are more viable when we are talking about another carrier. However, they also can be implemented for ISPs without cable ownership who are allowed to operate receive-only antennas," Bernstein says. "For the Globeinternet service, we have found a growing mix of satellite connections, which include full duplex E-1s (2.04 Mbps) or fractional E-1s along with asymmetric connections, such as E1/512 kbps and 8 Mbps/2 Mbps as well as simplex satellite E-3 (34 Mbps) and DS-3 links."

Bernstein is convinced that despite the growing number of new cable systems, IP-over-satellite has a strong future.

"Simplex satellite links allow carriers to fill up their existing cable capacity (inbound to the United States), which is under utilized because of the inherent asymmetry of Internet traffic. For the hybrid cable/simplex satellite link, capacity can be added incrementally just on the satellite link," Bernstein says. "Certain applications, such as point-to-multipoint and on-demand applications, are best served by satellite. Besides, many countries have no cable landing point, or a weak fiber infrastructure, or both. This makes satellite connectivity the only or the most viable approach."

COMSPEC DIGITAL: THE HUMVEE OF THE DATA BIZ

The demand for IP-over-satellite services has brought a new dimension to data transmission, but it would be more than a bit misleading to portray IP-over-satellite as the ideal solution in all circumstances.

Thomas A. Paine, president of Comspec Digital Products Inc. (Comspec DPI) in Houston likes to move big files—very big files—from remote places. Many of his clients are big energy companies that have to move oil and gas exploration data from the far corners of the world. He is able to move data under the toughest conditions. His preference is definitely the Inmarsat B land mobile and marine terminals with High Speed Data (HSD) at 64 kbps.

"We can handle data circuits with 50 percent packet errors, and our transfer time will

Circle Reader Response 16

only double. Three percent packet errors will stop an IP link. We specialize in data communications in stressed environments. You can call us the Humvee of the data communications world," Paine says. "We've designed our own protocol. We're not versatile, we're not flexible, and we're definitely not interactive. On Inmarsat HSD, it might take us four hours to move 100 megabytes pre-compressed from 1 gigabyte, but we can move it through circuit errors, link loss and even power failures."

IP-over-Internet is chock full of what Paine describes as, "superfluous traffic that is slowed by others you do not control." According to Paine, the Internet is not the right place to be when you have to guarantee 100 percent reliability—regardless of the speed—from some remote region. That's the type of stressed environment where Comspec DPI thrives.

"Inmarsat is where you want to be if you just want to pop up, send something and then go away. It's an on-demand-type service where you pay by the minute. This offers distinct advantages," Paine says.

IP-OVER-SATELLITE SERVICES: ONLY THE BEGINNING

Voice over IP and other new services are bound to ensure a steady growth for IP-over-satellite. As we have demonstrated here, many satellite service providers are aggressively pursuing new IP-based strategies. In June, for example, NetAccess, a Philadelphia-based ISP, began using GE Americom's new DVB-based ISP-Sat service to downlink Usenet newsgroup feeds. Also, Scientific-Atlanta is introducing its Powervu IP system, Gilat has its Websat VSATs, Media4 has its Mediastream system and Ottawa-based International Datacasting Corp. (IDC) has its Superflex system.

"Customer education is the biggest obstacle," says Joe Amor, vice president and general manager of Microspace Communications Corp. in Raleigh, NC. Microspace's launched its Velocity MPEG 2/DVB video and high-speed data service earlier this year. Seachange International Inc., a leader in the video-on-demand sector, is one of Microspace's clients. Seachange is using velocity for digital ad distribution.

Competing transmission methods to satellite are also rising to the challenge. Still, IP-over-satellite is a proven technology with widespread applications. What will be the driving forces propelling this phenomenon? Lower cost storage devices, new software-based solutions, new network and traffic management tools will all allow IP-over-satellite service providers to achieve maximum operating efficiency combined with the highest quality of service. And in many instances, a CIR-based services menu only adds to the overall attractiveness of the whole concept.

Recent announcements from Interpacket Group, San Francisco-based Charter Communications International and U.K.-based Kingston Satellite Services, using Skystream Corp's DBN-25 Integrator, demonstrate that demand is escalating and IP-driven revenue is pouring in.

PETER J. BROWN HAS BEEN TRACKING THE SATELLITE AND DTH SECTORS IN THE U.S. AND CANADA AS A FREELANCE WRITER SINCE THE MID-1980S. HE LIVES ON MOUNT DESERT ISLAND, MAINE.

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Communications via satellite. Many say it became the brightest jewel in the whole treasure chest. Of all the scientific and technological marvels from the first four decades of the National Aeronautics and Space Administration (NASA), which celebrates its 40th anniversary this month, nothing else has become so profitable.

NASA AT 40

THE EARLY YEARS PAY OFF

By Robert N. Wold

Via Satellite's Global Satellite Survey pointed out in July that the earth is covered by a record 192 geostationary, commercial communications satellites, and 67 more are on order. These figures don't include the low- and medium-orbit satellites for the mobile telecommunications systems of Iridium, Globalstar, ICO and others.

Merrill Lynch forecasts the satellite communications industry will produce annual revenues of $67.3 billion by 2001. Another study, the 1998 *State of the Space Industry*, pegs total space-related revenues in 2001 at $117 billion with "telecommunications" representing 35 percent of that amount.

The satellite communications industry, however large its revenue forecasts are from various market studies, owes a lot to the extensive federal government funding through NASA for research and development in the late 1950s, early 1960s and beyond.

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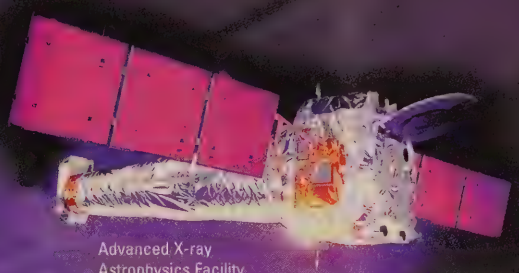

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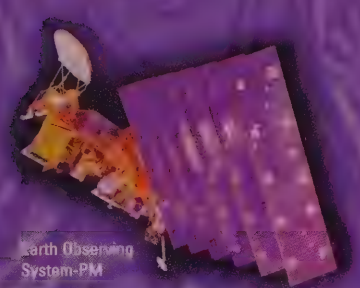

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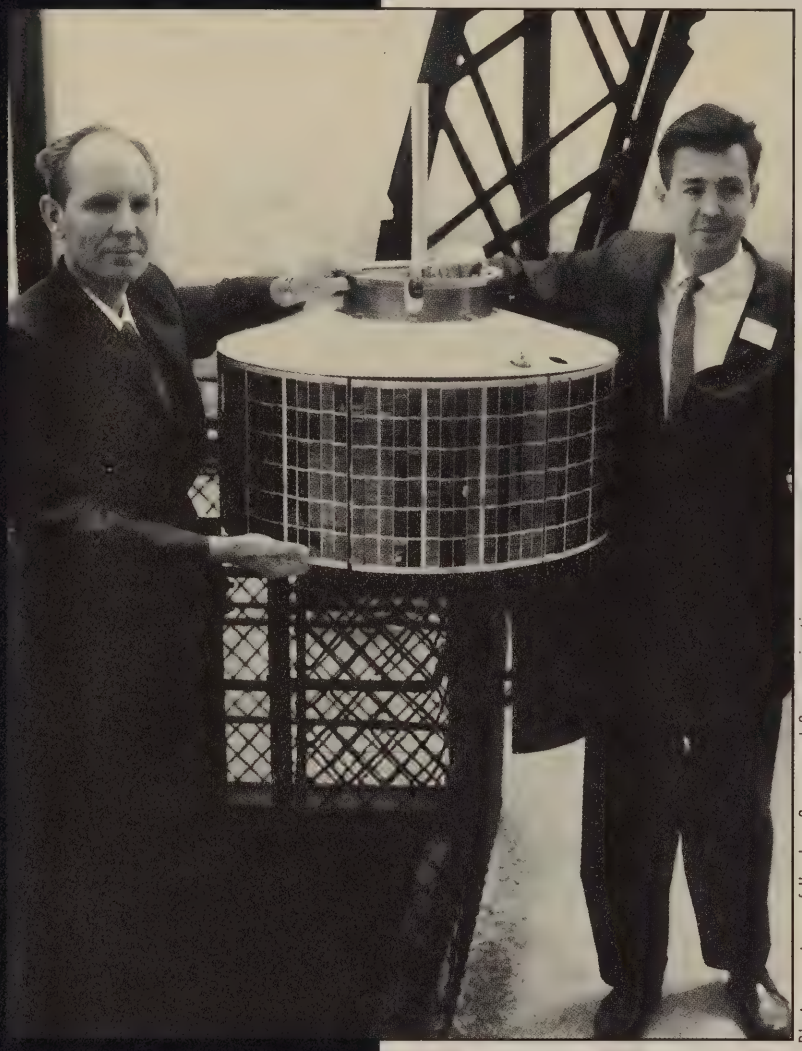

Photo courtesy of Hughes Space and Communications.

This historic picture on top of the Eiffel Tower commemorates Rosen and Hudspeth demonstrating Syncom at the 1961 Paris Air Show.

In its Applications Program, NASA was confident from the beginning that spacecraft placed in orbit by powerful boosters—artificial satellites, call them—could prove invaluable for communications, weather analysis and earthquake predictions, just for openers.

Forty years later we accept communications satellites in stride. So smoothly done is the work, we're unaware of their presence.

PREPARING FOR THE SIXTIES

Today's relative indifference toward such miracles was inconceivable during the five roller coaster years from 1960 to 1964, encompassing the first phase of NASA's longterm R&D program for communication satellites.

Space historians remind us the roots for communications satellites were in rocket science. After all, they say, satellites wouldn't be in orbit if it weren't for those big boosts from converted intercontinental ballistic missiles once known to many as rockets.

NASA therefore supervised the launches for most of the experimental projects, engaging the Air Force to provide the actual boosters, mostly at Cape Canaveral, FL.

The military services were very involved in space. The Army, Navy and Air Force all had ambitious space and/or satellite programs in the 1950s and 1960s.

Many observers predicted that NASA would find the Department of Defense (DoD) and its military services to be difficult "competitors." To the contrary, DoD leaders such as John H. Rubel pushed strongly for a high level of cooperation with NASA.

The Central Intelligence Agency (CIA) also became a significant player, secretly of course. It managed the successful U-2 photo reconnaissance airplane program, followed by the satellite program now known as Corona. (The "research" satellites in this project had a cover name, Discoverer.)

With the establishment of NASA, the United States was enabled to separate scientific and commercial developments in space from military and security projects.

DR. ROSEN REMEMBERS

Memories of yore come easily for Dr. Harold A. Rosen of Los Angeles and, no doubt, Dr. John R. Pierce of Stanford, CA.

Remember those accolades from satellite prophet Sir Arthur C. Clarke? While humbly accepting the sobriquet of satellite communications' godfather, Clarke firmly added, "The *true fathers* of all this are Dr. Harold Rosen and Dr. John Pierce."

Both Rosen and Pierce were front riders on the NASA roller coaster.

For Hughes Aircraft Co., where Rosen was then assistant manager of the radar department, to win a development contract for its unique comsat concept from either DoD or NASA was no simple matter. Political and bureaucratic obstacles were proliferate.

From initial meetings in 1959, when design work had begun, it wasn't until September 11, 1961, that Hughes won a sole-source project development contract from NASA, in which the DoD would participate.

Rosen's engineering team—including Donald D. Williams, Thomas Hudspeth and others—had developed a spinning configuration with distinctive simplifications in the equipment needed for orbit and attitude control.

Called Syncom—for synchronous communications—it had to be light enough to enable a booster to deliver it all the way up to what is now called the geostationary satellite arc.

The scientific community had observed their military brethren struggle with Project Advent, a synchronous satellite constructed by General Electric with every possible bell and whistle the military services could think of including.

Advent's main problem was that it weighed some 590 kg (1,300 lbs.), and the Centaur booster it needed was far from

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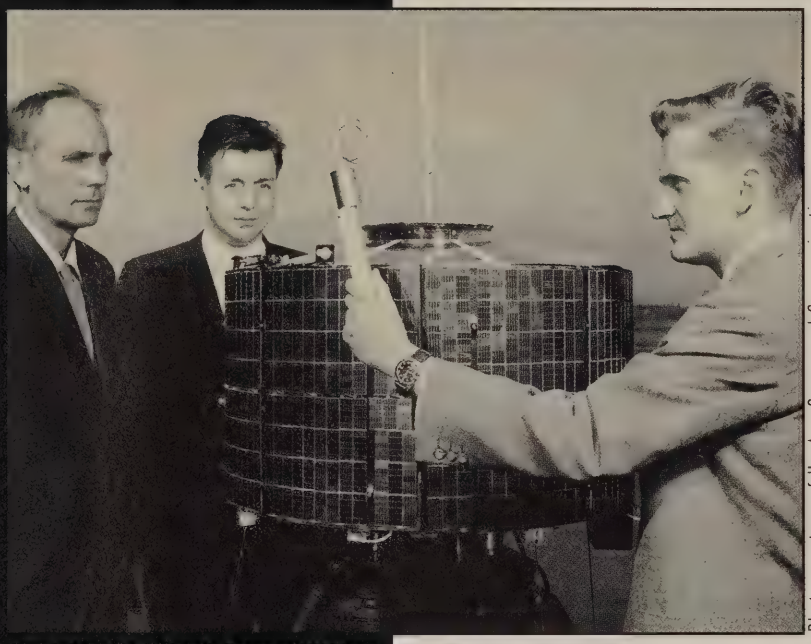

Photo courtesy of Hughes Space and Communications.

From left to right, Hudspeth, Rosen and Williams pose with Syncom. Williams is holding a specially designed travelling wave tube.

being ready. Advent was cancelled by the DoD in late 1962.

So the synchronous opportunity was squarely in the laps of the Hughes team.

For Rosen, age 36 at the time, the biggest day in his life was to be Valentine's Day, 1963, at the Eastern Test Range (Eastern Space and Missile Center) at Cape Canaveral.

Hughes' first edition of Syncom was poised vertically on the gantry, ready for a Delta boost and the magical first entry by any type of satellite into synchronous orbit.

In five hours, Syncom 1 had safely climbed to its incredible target altitude of 35,881 km (22,300 miles). And then, disaster struck.

"After years of struggle," Rosen recalled for this interview, "all our hopes were riding on this first Syncom. And then, when the apogee kick motor was just about one second from finishing its firing, it blew up.

"Since then, nothing has been heard from that Syncom. It was a terrible disappointment for everyone involved."

In the view of NASA, Project Syncom was nevertheless promising. Leonard Jaffe, director of communications systems, noted that Syncom 1 "achieved a 33° inclined orbit with a period of nearly 24 hours," and that it was the first satellite to get "into nearly synchronous orbit."

NEXT: SYNCOM 2

On July 26, 1963—a bit more than five months later—Syncom 2 was ready to go.

"We made a lot of changes," Rosen says, "but the space agency was especially concerned that this one must not fail. For a

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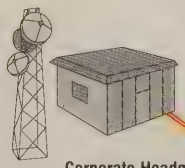

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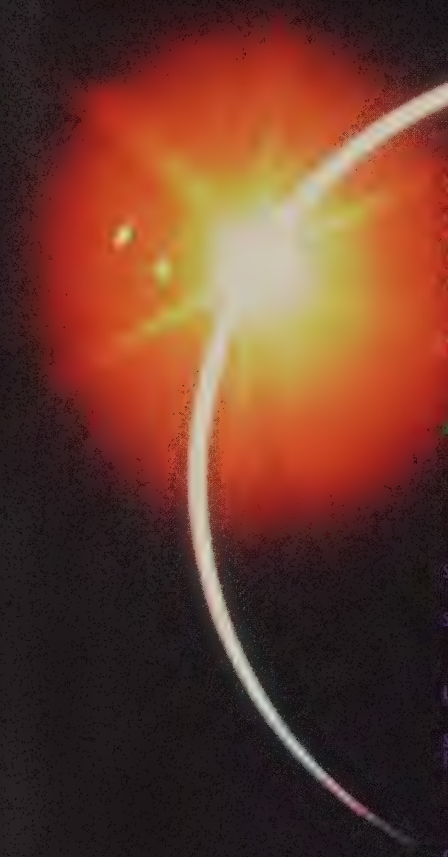

SATELLITE 99 offers keynotes, technical sessions and an exhibition that focus on the manufacture, launch and operation of satellites. Programs will also address the latest applications and market demand for satellite services.

These topics will be featured during SATELLITE 99:

Satellite Finance:
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- Funding New Growth: View from Investment Bankers
- Working with Wall Street: View from the Industry
- Satellite Insurance: Securing Celestial Assets

Satellite Manufacturing:
- Building for the Future

Satellite Operations:
- Mobile Satellite Leaders Roundtable
- Ka-Band: Closer to Reality?

Launch Vehicle Services:
- A Brave New World

Satellite Industry Studies and Forecasts:
- Global Satellite Industry Leaders Roundtable
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- Regulatory Beat: Cutting Through the Red Tape

Global Satellite Service Marketing:
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- Global DBS Update

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(One Day Forum—Thursday, February 4, 1999)
- When the Pagers Went Silent
- The Satellite-Wireless Connection

GPS Strategic Directions 99
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- GPS and Other Emerging Applications: How They'll Affect You
- EGNOS and GLONASS: What's Next?
- Wireless/GPS Integration: Fears and Forecasts

Global Airspace 99
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- Acronym Shuffle: GNSS, WAAS, LAAS, EGNOS, ADS-B
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- The March Toward Commercial Services
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Extend your stay by one day, and add on a pre-conference program (both held on Tuesday, February 2, 1999):

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Phillips 1998 SATELLITE INDUSTRY DIRECTORY

SCHEDULE OF ACTIVITIES (as of September 1, 1998)

UESDAY, FEBRUARY 2, 1999

:30 am-6:00 pm	Satellite Finance and Investment Summit
:00 am-5:30 pm	Satellite Basics Seminar
:00 pm-7:00 pm	Registration
:00 pm-11:00 pm	Phillips Satellite Group Reception

EDNESDAY, FEBRUARY 3, 1999

:00 am-5:30 pm	Registration
:00 am-11:00 am	SATELLITE 99 Opening General Session
1:15 am-12:45 pm	1999 Satellite Broadcast Forum
1:15 am-12:45 pm	GPS Strategic Directions 99
1:00 am-5:00 pm	Exhibit Hall Open
1:30 am-2:00 pm	Washington Space Business Roundtable Luncheon
:00 pm-3:30 pm	SATELLITE 99 Sessions
:00 pm-3:30 pm	1999 Satellite Broadcast Forum
:00 pm-3:30 pm	GPS Strategic Directions 99
:30 pm-4:00 pm	Refreshment Break in the Exhibit Hall
:00 pm-5:30 pm	SATELLITE 99 Sessions
:00 pm-5:30 pm	1999 Satellite Broadcast Forum
:00 pm-5:30 pm	GPS Strategic Directions 99
:00 pm -7:00 pm	SSPI Reception
:00 pm-11:30 pm	SSPI Banquet

THURSDAY, FEBRUARY 4, 1999

7:00 am-6:00 pm	Registration
8:30 am-10:00 am	SATELLITE 99 General Session
8:30 am-10:00 am	Global Airspace 99
10:30 am - 12:00 pm	SATELLITE 99 Sessions
10:30 am-12:00 pm	WB&T 99 The Wireless and Satellite Connection
10:30 am-12:00 pm	Global Airspace 99
10:30 am-12:00 pm	MilSat 99 Military Satellite Communications
12:15 pm-1:45 pm	SATELLITE 99 Keynote Address & Luncheon 1998 Satellite Executive of the Year Award Presentation
2:00 pm-3:30 pm	Global Airspace 99
4:00 pm-5:30 pm	SATELLITE 99 Sessions
4:00 pm-5:30 pm	WB&T 99 The Wireless and Satellite Connection
4:00 pm-5:30 pm	Global Airspace 99
4:00 pm-5:30 pm	MilSat 99 Military Satellite Communications
6:00 pm-7:30 pm	1998 Satellite Executive of the Year Reception

FRIDAY, FEBRUARY 5, 1999

8:00 am-1:00 pm	Registration
9:00 am-10:30 am	SATELLITE 99 General Session
9:00 am-1:00 pm	Exhibit Hall Open
11:00 am-12:30 pm	SATELLITE 99 General Session

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week they kept examining everything, pursuing all kinds of hypothetical problems."

The night before the launch, a "real" problem did occur.

Rosen recalls vividly, "The communications repeater started oscillating badly so Tom Hudspeth and I, with some others, went to the top of the gantry with a spectrum analyzer. Tom found the reason for the oscillating was that the antenna was folded back onto the spacecraft while in launch position. We hadn't pretested that."

Using a prototype to demonstrate, the Hughes team persuaded Jaffe and others from NASA that once the antenna erected, it would stabilize. The launch proceeded.

Rosen reflected, "I can't tell you what a big thrill it was when this one reached orbit successfully, the apogee motor fired, everything stayed on the air and we had a synchronous satellite. It was a wonderful feeling I'll never forget."

Syncom 2 provided NASA with the first TV, voice and facsimile experiences using a satellite in 24-hour-a-day orbit and became the first satellite maneuvered to a specific longitude (55°W). It carried the first telephone call between heads of state and the first satellite communications press conference, according to Jaffe.

GEOSTATIONARY: GO FOR IT

Rosen remembers, "We were able to make many improvements in Syncom 3," which was launched more than a year later on August 19, 1964. "It was a big thrill," he adds, "when we reached geostationary and all the antennas watching no longer had to move."

For NASA's public demonstration purposes, arrangements had been made with Japan to transport NHK's live coverage of the 1964 Summer Olympics from Tokyo to the United States and elsewhere east and west.

"We were aware," he says, "that France and England had competed to be first to successfully downlink a video signal from the United States via Telstar. Because the British had a problem with their definition of circular polarization at Goonhilly, the French won."

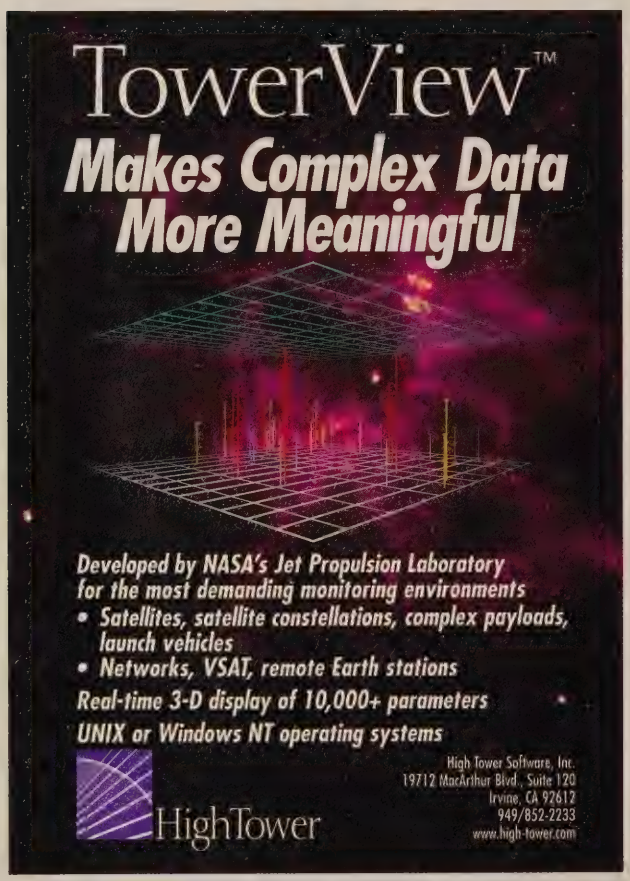
At the beginning of tests at the Point Mugu missile range in Southern California, where a highly sensitive ground terminal borrowed from the late Project Advent would be used to access Syncom 3's few watts of power, Rosen instructed the crew to be certain to get polarization coordinated with the Japanese.

"For some reason," Rosen recalls, "our Hughes team at Mugu began having signal problems. The first test signals were just awful, and it became nail-biting time. Lo and behold, the problem was polarization, just as it was for the British and Telstar." The problem was soon corrected.

The pictures were black and white, of course, and Syncom 3 had a very narrow-band system. "With things finally in hand at Mugu," Rosen says, "I was invited to see the live opening ceremonies at NBC's facilities in Burbank.

"It was spectacular. That fellow running into the stadium with the torch," he says, "is burned into my memory."

He marveled at the opening ceremonies and then, "watched the American Billy Mills come from back in the pack to win the 10,000-meter gold medal. Can you believe, we were watching all of it live!"



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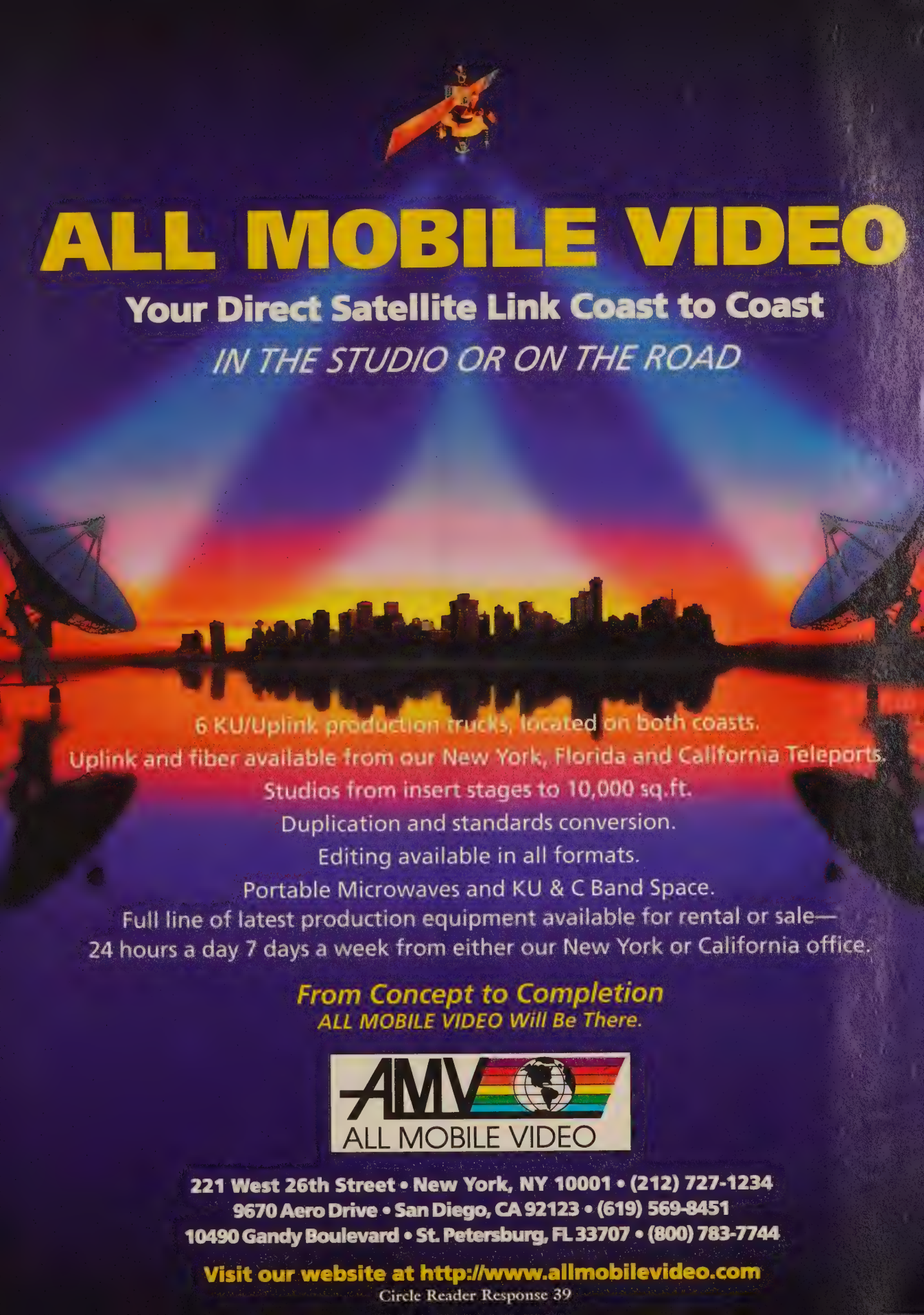
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EXPERIMENTAL COMMUNICATIONS SATELLITES, 1960-64

Launch Date	Satellite Name	Passive/ Active	Project Director	Manu-facturer	Launch Site*	Launch Vehicle	Weight (kg)	Period (minutes)	Perigee (km)	Apogee (km)	Inclin-ation (°)	Comments
8/12/60	Echo 1	Passive	NASA	NASA	ETR	Delta	75.9	118.2	1,524	1,684	47.2	First passive comsat; decayed 5/24/68
7/10/62	Telstar 1	Active	AT&T	AT&T	ETR	Delta	77.0	157.8	936	5,653	44.8	First active comsat; transmitted until 2/21/63
12/13/62	Relay 1	Active	NASA	RCA	ETR	Delta	78.0	185.1	1,317	7,442	47.5	Experiments conducted until 2/65
2/14/63	Syncom 1	Active	NASA	Hughes	ETR	Delta	39.0	1,425.5	34,392	36,739	33.3	Communications lost at orbital injection
5/7/63	Telstar 2	Active	AT&T	AT&T	ETR	Delta	79.0	225.3	966	10,808	42.7	Transmitted until 5/65
7/26/63	Syncom 2	Active	NASA	Hughes	ETR	Delta	39.0	1,454.0	35,584	36,693	33.1	First geosynchronous satellite
1/21/64	Relay 2	Active	NASA	RCA	ETR	Delta	78.0	194.7	1,993	7,508	46.3	Experiments conducted until 9/26/65
1/25/64	Echo 2	Passive	NASA	NASA	WTR	Thor/ Agena B	256.0	108.8	1,029	1,316	81.5	First joint program with USSR; decayed 6/7/69
8/19/64	Syncom 3	Active	NASA	Hughes	ETR	TAD**	39.0	1,407.8	34,191	36,271	0.1	First geostationary satellite

*ETR=Eastern Test Range, Cape Canaveral, FL; WTR=Western Test Range, Vandenberg AFB, CA

** Thrust Augmented Delta

Source: TRW Space Log.

NBC had an exclusive license to show the 1964 Summer Olympics on U.S. television, but their plans had been to fly videotape to New York from Tokyo for delayed broadcasts.

When the U.S. government, coordinating with a very new Comsat Corp., arranged with NASA to import the live coverage, NBC used some of it and shared portions with the nation's other TV networks, ABC and CBS.

Pictures also went to Canada and Europe, the latter region receiving—pardon the pun—a relay via Relay.

In the course of a few days, the expectations of future television were changed forever.

PROJECT ECHO

Three other communications satellite projects rode on NASA's 1960-64 roller coaster.

Dr. John R. Pierce—one of the communication satellite industry's pair of "fathers," involved Bell Laboratories in both Project Echo and Project Telstar.

Echo 1 was a passive reflector balloon launched on August 12, 1960.

All of the other 1960s projects were for active repeater, as opposed to passive, satellites. Yet Echo became, in the words of NASA's Jaffe, "one of the best ambassadors

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the United States ever had inasmuch as it was clearly visible to millions of people throughout the world."

Passive communications—in which the satellite acts like a mirror—were first explored in signal "bounces" off the moon by the Army's Signal Corps in 1945 and later by the Navy's project "Communications by Moon Relay" (CMR), which began in 1954.

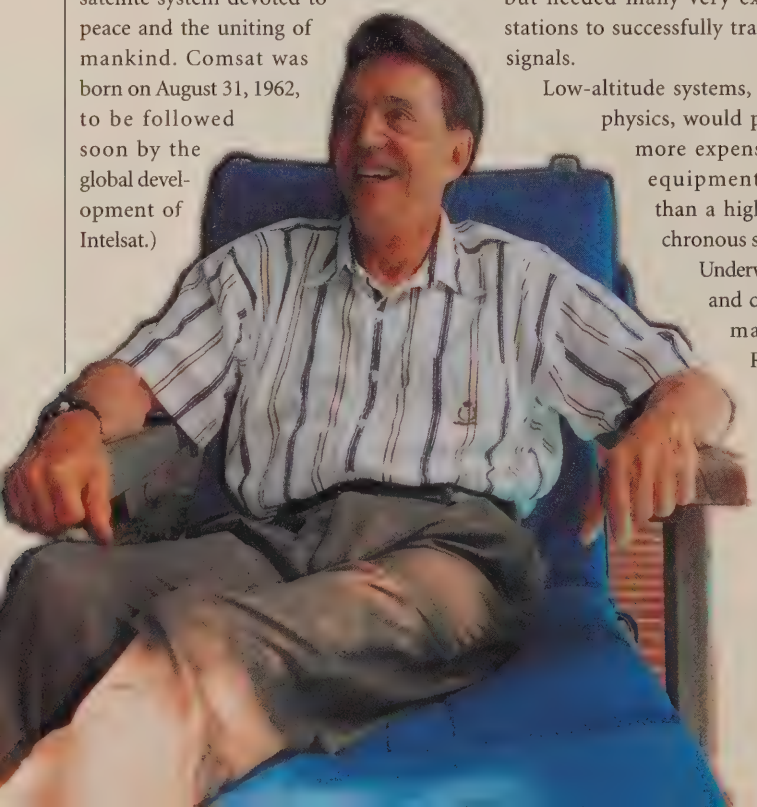
Pierce and Bell Laboratories were extremely supportive of the principles of Echo, which carried a large number of well-planned communications experiments, both domestically and internationally.

Echo 1's thousand-mile-high circular orbit of a 100-foot Mylar balloon continued for more than four years. Echo 2, launched January 25, 1964, included a joint test with the Soviet Union.

PROJECT TELSTAR

AT&T was pursuing politically the right to dominate ownership of the U.S. portion of an international satellite communications enterprise advocated by new President John F. Kennedy in his May 25, 1961, speech to a special session of Congress on urgent national needs.

(From this speech, most memorable was the Project Apollo challenge, to land a man on the moon and return him safely. But JFK also called for a global communications satellite system devoted to peace and the uniting of mankind. Comsat was born on August 31, 1962, to be followed soon by the global development of Intelsat.)



Using its Bell Laboratories expertise, AT&T wanted to illustrate to Congress and the public how skillfully it could operate satellite communications.

In a bid to construct and operate NASA's Project Relay, a low-altitude, active-repeater satellite experiment, AT&T lost out to RCA. AT&T then offered to pay all costs to demonstrate a project similar to Relay. Its offer was approved, and Project Telstar was underway.

Telstar 1 was launched amid much fanfare on July 10, 1962, and its sequel, Telstar 2, on May 7, 1963. Many research accomplishments were achieved. Highlights of Telstar's pioneering accomplishments included trans-Atlantic television transmissions, connecting the United States with France and England, and some 300 successful technical tests of telephony, data, facsimile and telephoto transmissions.

For AT&T, the large investment in Telstar's experimental success was politically empty, as Congress voted to establish the new Communications Satellite Corp., in which AT&T could be only a minority owner.

PROJECT RELAY

Being orbited far below the 24-hour-a-day synchronous altitude of Syncom, both Telstar and Relay avoided propagation (voice delays) in two-way telephony but needed many very expensive earth stations to successfully track the satellite signals.

Low-altitude systems, by the laws of physics, would prove to be far more expensive in capital equipment investments than a high-altitude synchronous system.

Underwritten by NASA and constructed primarily by RCA, Relay 1 flew on December 13, 1962, and Relay 2 launched on January 21, 1964. The Relay satellites were credited with numerous communications "firsts."

Relay 1 provided the first satellite communications links between the United States and South America with Japan and with Germany and Scandinavia.

In a TV demonstration beamed from the United States to Japan, Relay provided live news of the assassination of President Kennedy in November 1963.

The 1964 Winter Olympics were sent by satellite from Innsbruck, Austria, to the United States and the 1964 Summer Olympics in Tokyo—delivered by satellite to the United States via Syncom 3—were then shipped to European broadcasters via Relay, most if it in "real time."

"EARLY BIRD"

Comsat put out requests for proposals for its first satellite and decided upon the clear winner in NASA's roller coaster ride of 1960-64. In 1964 it selected Hughes to construct the Early Bird satellite, the first baby for the upcoming Intelsat system.

The design was modeled after Hughes' successful Syncom 3 with an authorized change in frequencies from experimental to commercial. Hughes called it an HS 303. Early Bird (later Intelsat 1) launched on April 6, 1965.

Syncoms 2 and 3 were handed off by NASA to the DoD in April 1965. These two roller coaster veterans continued performing until they were turned off in 1969.

DR. PIERCE SUMMARIZES

In summarizing the events of 1960-64, Dr. Pierce wrote in 1968, "Syncom is the outcome of the bold and ingenious belief of a group of engineers at Hughes Aircraft Co. that one could make an extremely small but reliable synchronous satellite (in the 22,300 mile orbit first proposed by Arthur C. Clarke), and successfully launch it with the rather small Thor-Delta vehicle used to launch such low altitude satellites as Echo, Telstar and Relay."

Gracious words from one communications satellite "father" to the other.

California-based Robert N. Wold is a writer specializing in the history of electronic communications. He may be reached at 949/363-0993, fax: 949/363-2093 or e-mail: robertnwold@home.com.

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Earth Station High Power Amplifiers

KPA, TWTA or SSPA?

THE HIGH POWER AMPLIFIER (HPA) IN AN EARTH STATION FACILITY PROVIDES THE RF CARRIER WITH POWER TO THE INPUT TERMINALS OF THE ANTENNA THAT, WHEN COMBINED WITH THE ANTENNA GAIN, YIELDS THE EQUIVALENT ISOTROPIC RADIATED POWER (EIRP) REQUIRED FOR THE UPLINK TO THE SATELLITE. THE WAVEGUIDE LOSS BETWEEN THE HPA AND THE ANTENNA MUST BE ACCOUNTED FOR IN THE CALCULATION OF THE EIRP.

by Robert A. Nelson

The output power typically may be a few watts for a single data channel, around a hundred watts or less for a low-capacity system, or several kilowatts for high-capacity traffic.

The choice of amplifier is highly dependent on its application, the cost of installation and long-term operation and many other factors. This article will summarize the technologies, describe their important characteristics and identify some issues important to understanding their differences and relative merits.

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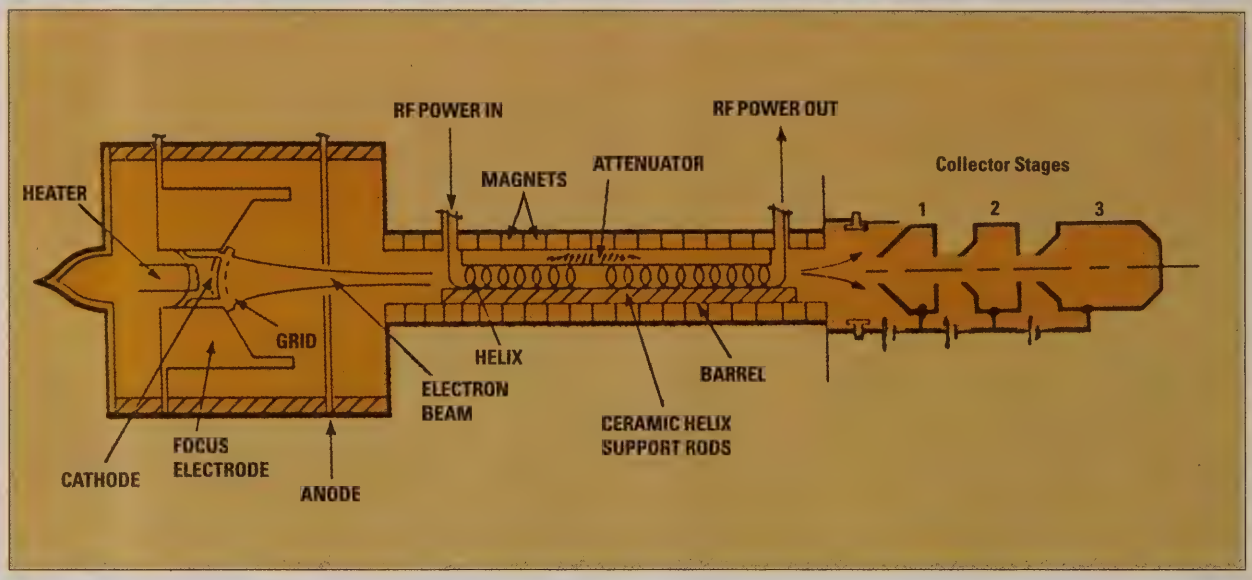

This diagram illustrates the configuration of a typical travelling wave tube.

TYPES OF AMPLIFIERS

Earth station terminals for satellite communication use high-power amplifiers designed primarily for operation in one of several bands. These include the fixed satellite service (FSS) at C-band (6 GHz), military and scientific communications at X-band (8 GHz), fixed and mobile services at Ku-band (14 GHz), the direct broadcast service (DBS) in the DBS portion of Ku-band (18 GHz) and military applications in the EHF/Q-band (45 GHz). Other frequency bands include those allocated for the emerging broadband satellite services in Ka-band (30 GHz) and V-band (50 GHz). Generally, the frequency used for the earth-to-space uplink is higher than the frequency for the space-to-earth downlink within a given band.

An earth station HPA can be one of three types: a klystron power amplifier

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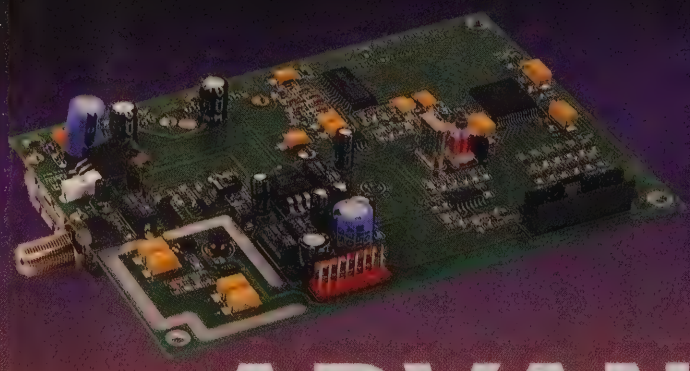
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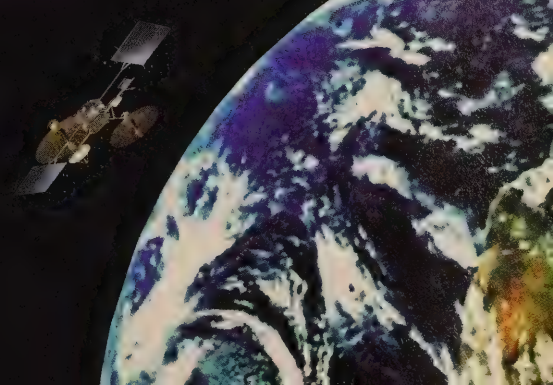

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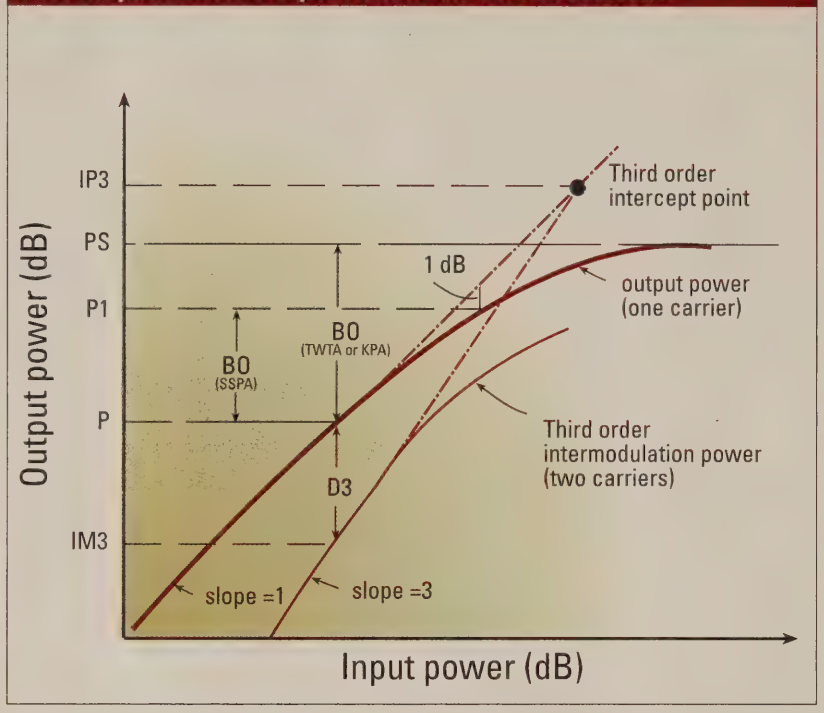
HPA Output Power Vs. Input Power Transfer Characteristic



(KPA), a traveling wave tube amplifier (TWTA) or a solid state power amplifier (SSPA). The KPA and TWTA achieve amplification by modulating the flow of electrons through a vacuum tube. Solid state power amplifiers use gallium arsenide (GaAs) field effect transistors (FETs) that are configured using power combining techniques. The klystron is a narrowband, high-power device, while TWTAs and SSPAs have wide bandwidths and operate over a range of low, medium and high powers.

The principal technical parameters characterizing an amplifier are its frequency, bandwidth, output power, gain, linearity, efficiency and reliability. Size, weight, cabinet design, ease of maintenance and safety are additional considerations. Cost factors include the cost of installation and the long-term cost of ownership.

KPAs are normally used for high-power narrowband transmission to specific satellite transponders, typically for television program transmission and distribution. TWTAs and SSPAs are used for wideband applications or where frequency agility is required.

Originally, TWTAs provided high power but with poor efficiency and reliability. Compared to a KPA, these disadvantages were regarded as necessary penalties for wide bandwidth. SSPAs first became available about 20 years ago. They were restricted to low-power systems requiring only a few watts, such as small earth stations transmitting a few telephone channels.

Within the past decade, however, TWTA and SSPA technologies have both advanced considerably. Today there is vigorous competition between these two technologies for wideband systems.

KPA

The klystron power amplifier (KPA) is a narrowband device capable of providing high power and high gain with relatively high efficiency and stability. The bandwidth is about 45 MHz at C-band and about 80 MHz at Ku-band. Thus a separate KPA is usually required for each satellite transponder.

In a klystron tube an electron beam is formed by accelerating electrons emitted from a heated cathode through a positive potential difference. The electrons enter a series of cavities, typically five in number, which are tuned around the operating frequency and are connected by cylindrical "drift tubes."

In the input cavity the electrons are velocity-modulated by a time-varying electromagnetic field produced by the input radio frequency (RF) signal. The distribution in velocities results in a density modulation further down the tube as the electrons are bunched into clusters when higher velocity electrons catch up with slower electrons in the drift tubes.

Optimum bunching of electrons occurs in the output cavity. Large RF currents are generated in the cavity wall by the density-modulated beam, thereby generating an amplified RF output signal. The energy of the spent electron beam is dissipated as heat in the collector.

The intermediate cavities are used to optimize the saturated power, gain and bandwidth characteristics. Additional bunching of electrons is provided, yielding higher gain.

The gain is typically 15 dB per cavity, so that a five-cavity klystron can provide a total gain of about 75 dB if synchronously tuned. However, by "stagger tuning" the individual cavities to slightly different frequencies, the bandwidth can be increased with a reduction in gain. A typical gain is on the order of 45 dB.

For a cavity device like a klystron, the bandwidth is a fixed percentage of the frequency of operation. The bandwidth is proportional to the frequency and inversely proportional to the Q (quality) factor, which is defined as 2π times the ratio of the energy stored and the average energy lost in one cycle. Thus at C-band (6 GHz), a typical bandwidth is 45 MHz. But at Ku-band (14 GHz) the bandwidth is about 80 MHz. These bandwidths are well suited for C-band and Ku-band satellite transponders. By adding a sixth, filter cavity the KPA bandwidth can be doubled. Thus 80 MHz KPAs are also available at C-band.

Klystrons can be made with "extended interaction" circuits in one or more cavities that increase the bandwidth substantially. This technology can provide a bandwidth of 400 MHz at 30 GHz. Output powers up to 1 kW can also be achieved at different bandwidths.

Although the bandwidth is relatively small, a conventional klystron can be mechanically tuned over a wide frequency range. A klystron can be capacitively or inductively tuned. All satcom klystrons are inductively tuned because of better efficiency and repeatability. The inductance is varied by moving a wall in the cavity (sliding short).

The output power of a KPA is about 3 kW at C-band and 2 kW at Ku-band. The lowest power KPA offered for commercial satellite communications is around 1 kW,

although for certain applications powers under 1 kW are available.

TWTA

The traveling wave tube amplifier (TWTA) consists of the traveling wave tube (TWT) itself and the power supply. The TWT can have either a helix or coupled-cavity design.

The TWT is a broadband device with a bandwidth capability of about an octave, which easily covers the 500 MHz bandwidth typical of satellites in the FSS. It also covers the typical 800 MHz DBS bandwidth requirement, as well as even broader bandwidths in Ka-band and higher bands.

The TWT, like the klystron, is an example of a device based on modulating the flow of electrons in a linear beam. The TWT differs from the klystron by the continuous interaction of the electrons with the RF field over the full length of the tube, instead of within the gaps of a few resonant cavities.

The TWT has a heritage of over half a century. The original concept was proposed in 1944 by Rudolf Kompfner, who investigated experimental laboratory microwave tubes while working for the British Admiralty during World War II.

Photo courtesy of CPI.

Travelling wave tube products are manufactured by a host of companies in the satellite industry, including this one from Communications and Power Industries (CPI).

The first practical TWT was developed at the Bell Telephone Laboratories in 1945 by John Pierce and L.M. Field. Bell Labs was interested in the technology for its possible application to communication. By the early 1960s, the TWT was adapted for use in satellite power amplifiers in the Telstar program.

In a TWT, amplification is attained by causing a high-density electron beam to

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interact with an electromagnetic wave that travels along a "slow-wave structure," which usually takes the form of a helical coil. A helix is the widest bandwidth structure available. The electrons are emitted from a heated cathode and are accelerated by a positive voltage applied to an aperture that forms the anode. The electrons are absorbed in a collector at the end of the tube.

The RF signal is applied to the helix. Although the signal travels at nearly the speed of light, its phase velocity along the axis of the tube is much slower because of the longer path in the helix, as determined by the pitch and diameter of the coil, and is nearly equal to the velocity of the electrons. For example, if the electrons are accelerated by a 3,000-volt potential difference on the anode, the speed of the electrons is about one-tenth the speed of light. Thus the length of the helix wire should be about 10 times the axial length of the tube to bring about synchronism between the RF traveling wave and the electron beam.

The electrons interact with the traveling wave and form clusters that replicate the RF waveform. Midway down the tube, an attenuator, called a "sever," absorbs the RF signal and prevents feedback, which would result in self-oscillation. On the other side of the attenuator, the electromagnetic field of the electron clusters induces a waveform in the helix having the same time-dependence as the original signal but with much higher energy, resulting in amplification. The gain is typically on the order of 40 to 60 dB.

The beam-forming optics are critical parts of the tube. To minimize heat dissipation caused by electrons striking the helix, the beam must be highly focused and the transmission from one end of the tube to the other must be close to 100 percent. When the electrons reach the end of the tube, they impact with the walls of the collector, where most of the heat is generated.

The efficiency of the tube can be improved by applying a negative potential to the collector, which retards the electron beam as the electrons enter it. A collector designed to operate in this way is called a "depressed collector." Less energy is converted to heat as the electron beam impinges on the collector, and consequently less energy is lost as thermal waste.

However, the distribution of electron energies is not uniform. In a multi-stage depressed collector, high-energy electrons are directed to stages with high-retarding fields and low-energy electrons are directed to stages with low-retarding fields. This configuration improves the efficiency further, but with greater complexity.

Another means of achieving greater efficiency is through improving beam synchronization. As the electrons travel along the tube and interact with the RF signal, they give up energy and lose velocity. Thus with an ordinary helix, they tend to fall behind the signal. This problem can be mitigated by brute force by increasing the accelerating potential but at the expense of degrading the TWT linearity.

A more elegant method is through the use of a tapered helix, in which the pitch of the helix decreases along the tube. The signal velocity is thus retarded to compensate for beam slowing. The selection of optimum helix configurations has been made possible through advanced computer modeling techniques.

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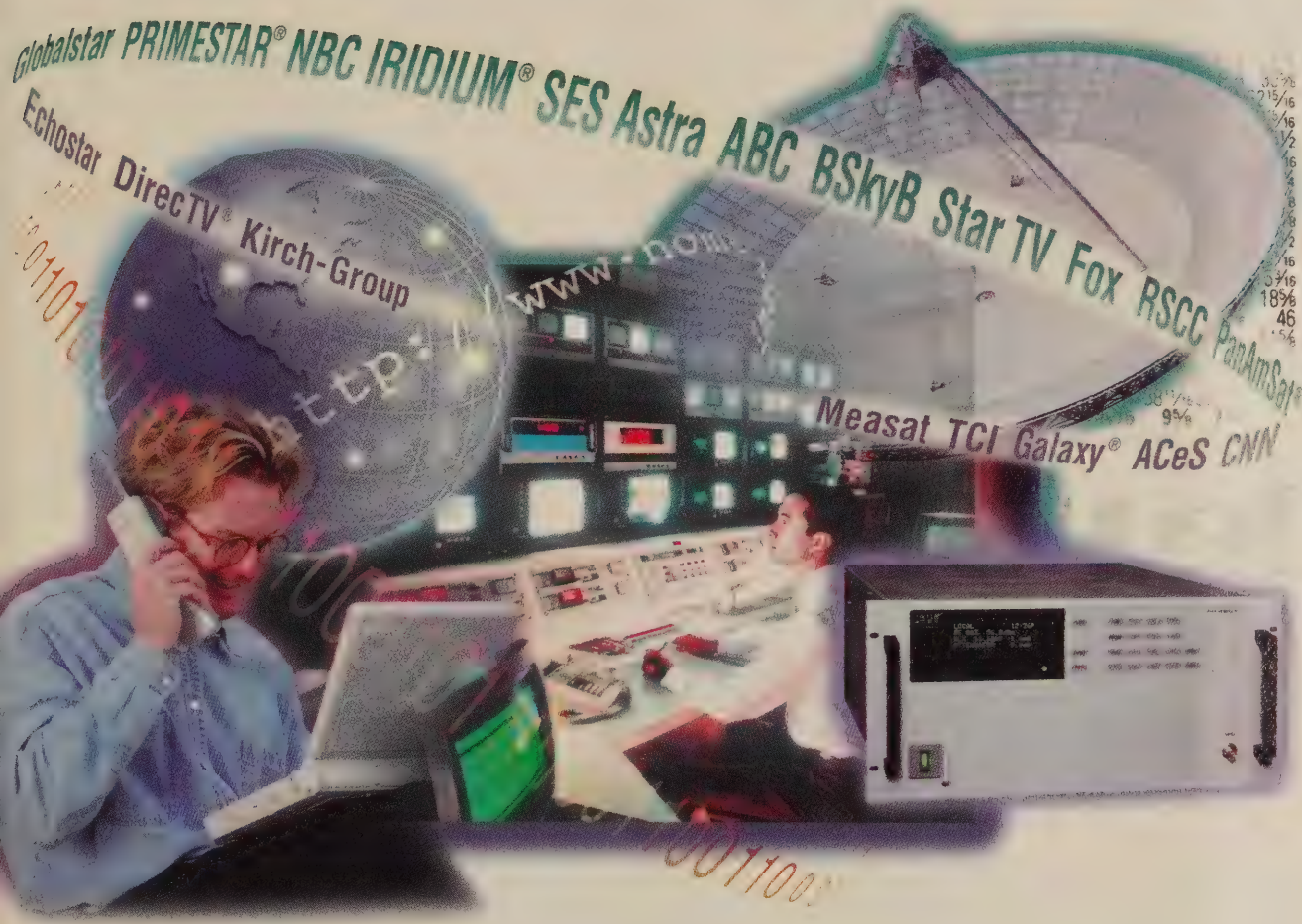
Situation: Critical
Solution: CPI Amplifiers



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Another type of TWT is a coupled-cavity device, used for high-power applications. In this case a series of cavity sections are connected to form the slow-wave structure and is similar to the klystron in this respect. However, in the klystron the cavities are independent, while in the TWT, the cavities are coupled by a slot in the wall of each cavity.

The output power of a helix TWTA at C-band ranges from a few watts to about 3 kW, while power levels of 10 kW can be attained with coupled-cavity TWTAs. Helix TWTAs at Ku-band have less power, with a maximum power of around 700 W.

Higher frequency TWTAs are also available, including those at Ka-band (20 to 30 GHz) and V-band (40 to 50 GHz) where new broadband satellite services are under development. However, because the market is not well established, there are fewer manufacturers of tubes at these frequencies.

The dimensions of the slow-wave structure—whether a helix, a coupled cavity or any other type—are determined by the frequency of operation. The product of wavelength and frequency is equal to the speed of light, so that as the frequency increases the wavelength decreases. The dimensions are proportional to the wavelength. Thus the structure dimensions are approximately inversely proportional to frequency. It is much more difficult to satisfy the criteria for operation at high frequencies, such as Ka-band or V-band than at C-band or Ku-band.

TWTAs for the new broadband services at Ka-band and V-band are also becoming available.

The gain of a TWTA can be from 45 dB to 75 dB, depending on the number of active wavelengths in the helix circuit.

SSPA

A solid state power amplifier (SSPA) uses a gallium arsenide (GaAs) metallic semiconductor field effect transistor (FET) as the amplifier gain element. The field effect transistor is a voltage-controlled, unipolar device that conducts only majority carriers and has good thermal stability. In contrast, an ordinary junction transistor is a current-controlled bipolar device, in which both minority and majority carriers participate in conducting an electrical current and can be thermally unstable. GaAs FETs can operate at higher frequencies than silicon devices, but the power output is limited by the poor thermal conductivity and lower breakdown voltage.

The maximum continuous output power of a single microwave FET can be from a few watts to several tens of watts. The limiting factor is the generation of

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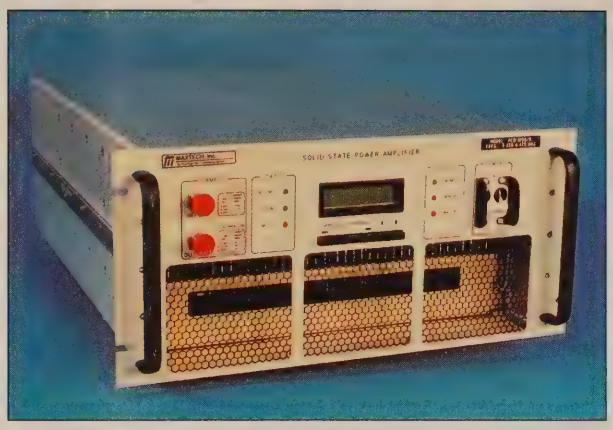

Photo courtesy of Maxtech.

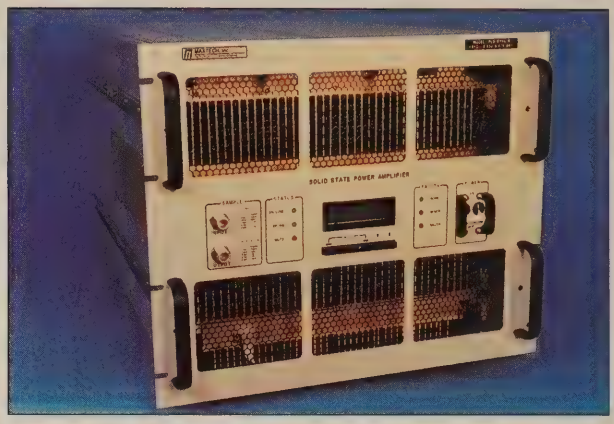

Photo courtesy of Maxtech.

Solid state power amplifiers (SSPAs) offer an alternative technology to the travelling wave tube. Like TWTAs, SSPAs come in a variety of power levels and configurations from maufacturers such as these products from Maxtech.

heat. At the thermal limit the maximum power is theoretically inversely proportional to the square of the frequency. Thus in the present state of the art, a typical GaAs FET at C-band might have a maximum output power of between 30 W and 45 W, while at Ku-band it is 15 W.

Transistors are combined to form modules. For example, a C-band module containing 12 FETs might be configured with four FETs in parallel in a power-combining output stage, preceded by an intermediate stage with two FETs in parallel and six driver stages in series with one FET per stage. Each FET has a gain of about 8 dB, so in this case, there are eight stages of amplification with a total gain, including losses, of about 60 dB or a factor of 1,000,000. If each of the four FETs in the final stage had an output power of 30 W, the total output power would be 120 W. With a gain of 60 dB, the input power to the first stage would be 0.12 mW.

Higher powers are obtained by assembling modules using standard power combining techniques. The modules are connected in parallel by waveguide elements, such as hybrids or magic tees, to obtain the required total output power. However, the number of parallel modules is limited by combination losses.

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Satellite Delivery Solution

The "Outernet" (SpectraCast® satellite Internet connections from "outer space") provides fast, high-quality, low-cost, universal Internet coverage. This breakthrough is critical because the "Web" is growing into an increasingly complex and congested connection of tiered backbones, POPs, and ISPs, with escalating transmission delays, errors, and costs.

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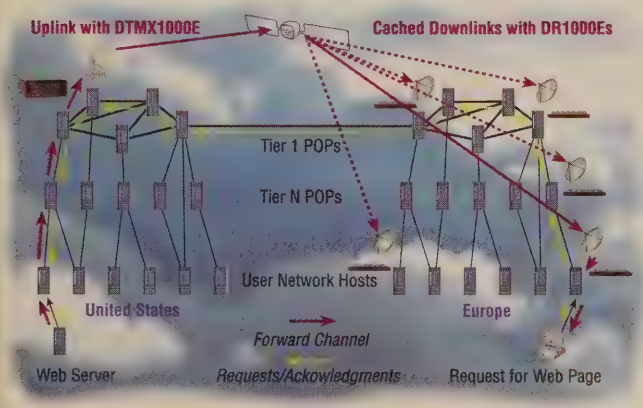

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SSPAs are readily available with rated powers up to about 500 W at C-band or 100 W at Ku-band.

A new solid state technology is the microwave monolithic integrated circuit (MMIC). This device combines active FETs with passive circuit elements that are deposited on a chip in a single process. The maximum power of a single MMIC is about 20 W at C-band and about 5 W at Ku-band. The total power can be increased by the combination of several MMICs in a series-parallel assembly, but is limited by combination losses that increase as the frequency increases.

Low-power MMICs are sometimes used as gain stages to drive high-power devices. MMICs can provide higher gain with less space and complexity than discrete low-power FETs.

LINEARITY

An important characteristic of any HPA is its linearity. This property is a measure of how well the transfer characteristic of output power vs. input power follows a straight line.

In practice, HPAs are inherently nonlinear devices. Nonlinearity means that the output power is not simply proportional to the input power. Instead, as shown in the figure on page 50, the graph representing the output power as a function of input power is more nearly represented by a third order polynomial than by a straight line. Thus there is a region of approximate linearity beyond which the graph curves downward and reaches a plateau.

The output power at this plateau is called the "saturated power" (PS). The saturated power is the maximum power that can be generated. The point of inflection on the curve that is 1 dB below the linear extrapolation is called the "1 dB compression point" (P1).

The transfer characteristic for an SSPA approaches saturation within about 1 dB of the 1 dB compression point, whereas for a TWTA or KPA, it bends more gradually, reaching saturation about 3 dB above this point. Therefore, an SSPA has superior linearity to that of a TWTA or KPA over the full range of operation to saturation. However, below the 1 dB compression point, the linearities are similar.

The physical effect of nonlinearity is the generation of harmonics of the fundamental carrier frequency. High-frequency harmonics can be eliminated by filtering. For example, at C-band the second harmonic is at 12 GHz and the third harmonic is at 18 GHz, which are well out of band.

For single channel per carrier (SCPC) frequency division multiple access (FDMA) systems, nonlinearity causes intermodulation interference among neighboring channels. The principal source of interference is the third order intermodulation (IM3) product, which comes from the cubic term in the polynomial representation of the transfer characteristic. This contribution to the nonlinearity generates frequencies formed by mixing the second harmonic of one carrier with the fundamental of another. Thus given two carriers with frequencies *f1* and *f2*, the intermodulation products will have frequencies $2f2 - f1$ and $2f1 - f2$, which are the same as the frequencies of adjacent channels if they are equally spaced, and cause unacceptable levels of interference. The figure of merit is the so-called two-tone "third order intercept point" (IP3),

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where the graph of the intermodulation power intercepts the graph of linear gain.

In this case, the HPA must have a "backoff" (BO) to operate at a power (P) in a region that is sufficiently linear where the intermodulation products are within acceptable limits as specified by the maximum carrier to interference power ratio (D3). This ratio may be estimated from the third order intercept and the single carrier output power by the relation D3=2(IP3-P).

Intermodulation interference does not exist if only one carrier occupies the entire bandwidth of the HPA, such as a single 36 MHz analog FM video channel in a KPA, or multiple wideband digital time division multiple access (TDMA) channels in a TWTA or SSPA. At any given instant the carrier occupies the full bandwidth of the HPA, and there are no neighboring channels with which to interfere. In this case, an HPA can be run at full saturated power.

RATED POWER

The comparison between TWTA and SSPA output power ratings has been obscured by differences in traditional measures of output power. For a TWTA, the rated power is the saturated power because TWTAs operate at this power for single carrier applications. On the other hand, for an SSPA the rated power is the 1 dB compression point. The "advertised" power of an SSPA is sometimes the saturated power, which is about 1 dB higher. No standards for equal comparison exist in the industry.

Another issue is the distinction between the output power of the TWT and the power at the TWTA output flange, which is about 0.5 to 0.7 dB lower. Allowance must also be made for tube aging. The power delivered to the output flange must be used in system planning. For example, a TWTA with a rated power of 400 W at saturation would actually deliver about 350 W to the antenna waveguide.

For multiple carrier operation, backoff is always referenced with respect to the rated power. A typical output backoff for a TWTA would be about 6 or 7 dB (with respect to saturation). Since every 3 dB corresponds to a factor of 2, a 6 dB backoff would deliver only one-fourth of the rated power. At the same intermodulation specification, an SSPA would require about 2 or 3 dB of backoff (with respect to 1 dB compression), delivering about half the rated power. Thus, as noted by TWTA industry representative Stephan Van Fleteren in *Satellite Online Magazine,* 6 dB of backoff in a TWTA would be roughly equivalent to 3 dB of backoff in an SSPA for the same 1 dB compression point.

For example, in SCPC FDMA applications a C-band TWTA rated at 400 W at saturation would have a practical output power of less than 100 W. On the other hand, an SSPA rated at 175 W at 1 dB compression (or 200 W at saturation) would have a similar practical output power. Therefore, in this situation, an SSPA rated at 175 W would be operationally equivalent to a TWTA rated at 400 W. They would each provide about -25 dBc separation for two-tone, third order intermodulation performance, which is a standard figure of merit for earth station operation (where dBc refers to the level in decibels of the spurious intermodulation product relative to the carrier).

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The same TWTA would have twice the useful power if combined with a linearizer. A linearizer is a network of solid state components that increases gain and phase lead as the input power increases, thus compensating for the gain reduction and phase lag as the TWT approaches saturation. The linearizer reduces the intermodulation level. The output backoff can be reduced by about 3 dB, thereby doubling the output power. Therefore, with a linearizer the traffic capacity could be doubled; alternatively, for a given capacity the required TWTA saturated power could be halved.

In the presence of rain fade, the KPA and TWTA have about 3 dB more margin than an SSPA for extra power when nominally operating in the linear region. There is a tradeoff between increased intermodulation interference and rain attenuation and noise that can be exploited with automatic power control.

At Ku-band, a typical 100 W SSPA has a power requirement of 1000 W for an efficiency of about 10 percent.

At Ka-band current off-the-shelf TWTA performance is 125 W with a typical efficiency of 20 percent. Current SSPA performance is less than 2 W at about 2 percent efficiency.

As another example, in multiple carrier operation a Ku-band TWTA rated at 125 W at saturation would deliver about 100 W at the output flange. With 6 dB of backoff, the useful power would be 25 W. The maximum prime power consumption would be about 650 W, but in this mode the input power would be about 500 W. The efficiency is thus 5 percent.

This unit would be operationally equivalent to an SSPA rated at 50 W at 1 dB compression, yielding 25 W of useful power with 3 dB of backoff. The prime power consumption would be approximately 550 W, so the efficiency is about 5 percent.

For the SSPA the power consumption stays the same, regardless of backoff and resulting output power.

EFFICIENCY

The efficiency may be defined as the ratio of the useful output power and the required prime power consumption. Values may differ with different definitions of output power. It is thus best to completely specify the conditions under which the efficiency is calculated. The efficiency depends on the output power and the frequency of operation. A few examples may be illustrative.

In single carrier operation, a typical C-band TWTA rated at 75 W at saturation delivers 70 W to the output flange and has a required prime power consumption of about 350 W. The efficiency is thus 70/350 = 20 percent. A C-band TWTA rated at 400 W delivers 350 W to the flange and requires about 1300 W for an efficiency of 27 percent, and a Ku-band 500 W TWTA delivers 450 W and requires 1900 W for an efficiency of 24 percent. TWTA efficiency has steadily increased, in part due to the development of depressed collector technology and improvements in beam focusing and synchronization.

A representative C-band 100 W SSPA at saturation requires a power of 700 W with an efficiency of about 14 percent.

For the SSPA the power consumption stays the same, regardless of backoff and resulting output power. Until about 10 years ago, this was also true for TWTAs. With multistage depressed collector technology, however, the required input power drops monotonically with output power, albeit not proportionately. Thus in this example, the efficiency of the TWTA is comparable to that of the SSPA.

The efficiency of a KPA is about 40 percent, which is relatively high compared to TWTAs and SSPAs.

RELIABILITY

Reliability is an important consideration in the design of a satellite communication system.

The overall reliability of a TWTA is affected by the failure rates of both the TWT and the power supply. The life-limiting factor of a TWT is cathode depletion. When SSPAs were introduced 20 years ago, TWTs used "B" type cathodes with a relatively short design life of less than 25,000 hours. These are dispenser cathodes made from porous tungsten and

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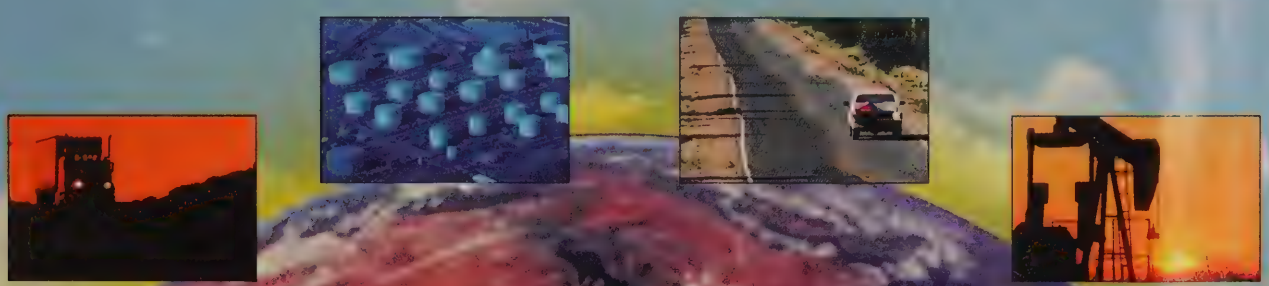

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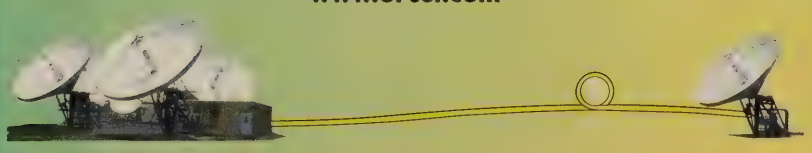

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filled with metallic compounds of barium, calcium and aluminum. The operating temperature is about 1000°C.

Today TWTs employ "M" type cathodes with a design life of over 100,000 hours. These cathodes have a surface layer of osmium, which due to the lower work function, enhances electron emission and allows a lower temperature to extend life. The TWT mean time before failure (MTBF) has also improved significantly, from approximately 8,000 hours to approximately 40,000 hours.

The overall TWTA reliability must include the MTBF of the high voltage power supply. The power supplies are susceptible to arcing if they become contaminated. Advances in power supply reliability have in part been the result of a large market for high voltage power supply circuit components with attendant high production and improved quality control. Components used in TWTAs also are used extensively in the consumer product industries to manufacture power supplies for microwave ovens, copiers and electronic equipment.

SSPAs are not subject to any known life limiting factors. They do not degrade with time, they use low voltage power supplies that are reliable and safe to operate, and they are not affected by vibration. However, SSPAs are sensitive to voltage spikes and fluctuations in temperature.

In redundant 1:1 configurations, the standby SSPA can be inhibited to save power with no penalty in switchover time if the primary SSPA fails. On the other hand, TWTAs have a long warmup time, which requires that the spare be kept in a ready-to-transmit state, consuming full power.

SSPA manufacturers say SSPAs have a MTBF 10 times better than that of a TWTA. Additionally, high-power SSPAs with multiple FETs in the output stage will continue to operate in the event of a FET failure, although at reduced power.

So far, no authoritative study has been performed on the failure histories of earth station high-power amplifiers. The principal data come from studies performed on space-borne satellite power amplifiers. A study of 2,400 amplifiers onboard more than 70 commercial satellites was reported by R. Strauss in the *International Journal of Satellite Communications* in 1993. Surprisingly, it was concluded that C-band TWTAs had about 33 percent better reliability than C-band SSPAs, while the reliability of Ku-band TWTAs was about the same as that of C-band SSPAs.

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SUMMARY

There is increasing competition between TWTA and SSPA technologies in C-band and Ku-band. SSPAs compete effectively with TWTAs in efficiency and cost for rated powers up to around 250 W in C-band and 50 W in Ku-band. In these bands TWTAs have several competitive advantages over solid state at higher power levels.

The performance of SSPAs is optimized at lower power levels, where their characteristics include better linearity, lower cost of ownership and improved safety because of lower voltages. Ease of maintenance is also a consideration, but replacement of the RF module cannot be done easily in the field.

As the power increases, the size and weight of the equipment must increase because of the need for heat sinks. Cooling is accomplished by either conduction or forced air systems.

At high frequencies, TWTAs dominate for high-power wideband applications, especially in Ku-band and beyond. At Ka-band and V-band, their advantages may become overwhelming. Present wideband amplifiers at Ka-band are all TWTAs. At this time SSPAs are not economically feasible in the DBS band or in Ka-band.

It is often stated that a lower power SSPA can replace a higher power TWTA in multiple carrier FDMA operation due to its superior linearity. However, the comparison may be misleading because of differences in definitions of rated power. In addition, if a linearizer is added, a TWTA will approach the performance of solid state but at higher cost.

When comparing backoffs, power outputs, and efficiencies, the different measures of rated power and any losses in the HPA must be taken into account. The issue of backoff is less critical for digital TDMA systems, where a dedicated earth station HPA is generally used for one carrier through a satellite transponder. Nevertheless, the earth station HPA is often operated at a typical backoff of 3 dB to compensate for degradation in bit error rate in PSK modulated transmission induced by nonlinearity, whereas the satellite transponder is operated close to saturation and its power can be fully utilized.

KPAs have high efficiency and are generally economical to operate. Traditionally, the klystron power amplifier has been a workhorse in the satellite communication industry. For narrowband systems with fixed frequency assignments, especially for television broadcasting, they remain an attractive alternative. The demand continues to grow and contemplated advances in design will further strengthen their role.

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Dr. Robert A. Nelson, P.E., is president of Satellite Engineering Research Corp., a satellite engineering consulting firm in Bethesda, MD, and is a contributing writer to *Via Satellite*.

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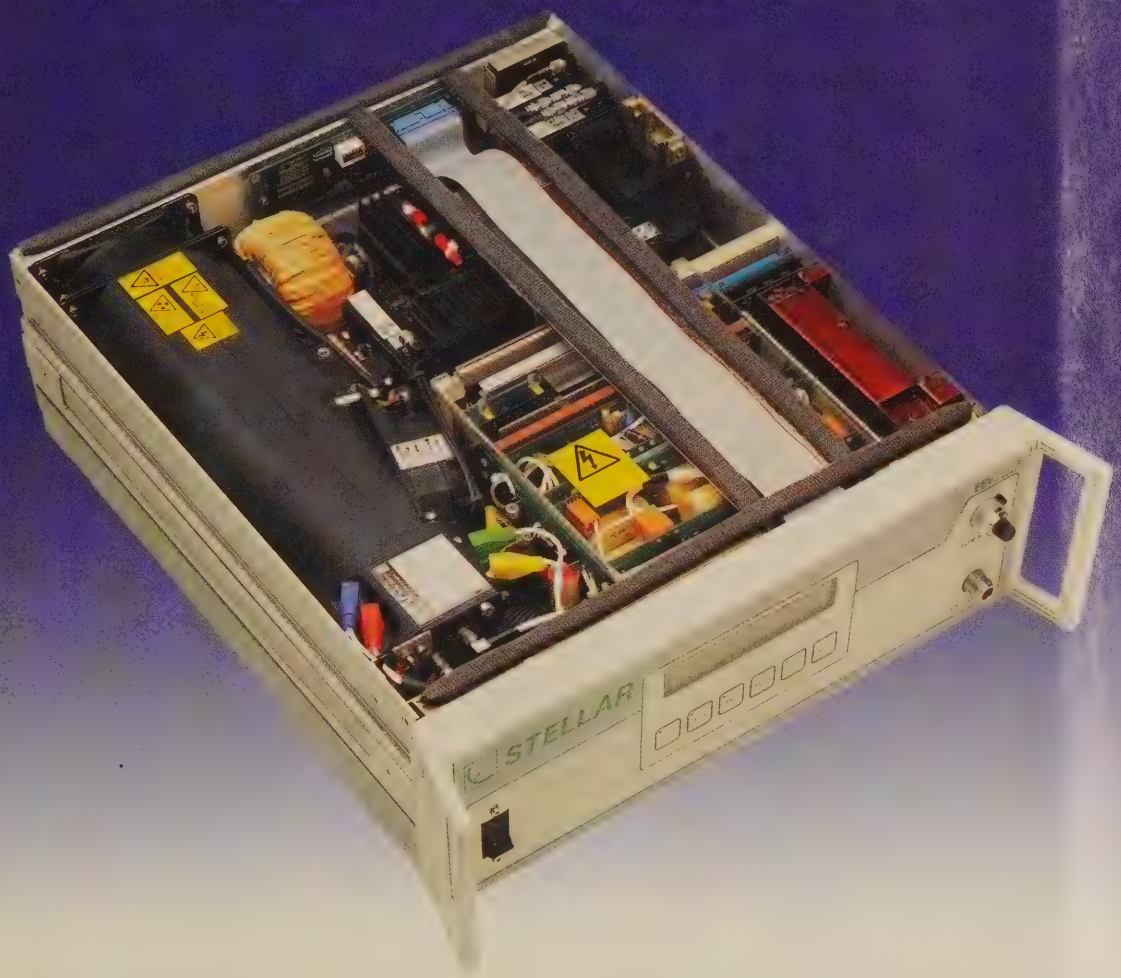

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Industry At Large

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People

Digitalxpress

New Chief Executive

Digitalxpress, a St. Paul-based provider of satellite communications services, appointed Amy Sayre as its new CEO. Sayre replaces Bill Bearry, who has been CEO of the company since its was established in 1996.

Sayre brings nearly 25 years of experience in engineering, manufacturing, quality assurance, program management, corporate auditing and business development to Digitalxpress. Sayre has worked for The Boeing Co., where she was director of business development for Boeing's commercial space subsidiary, which included Digitalxpress, Teledesic, Sea Launch and Resource 21.

New Skies

New CEO

New Skies Satellites selected Robert W. Ross as the CEO of the company. Ross has run his own broadcasting consulting business, Sattelenet, from Atlanta since 1996. Prior to this, he worked at the Turner Broadcasting System in a number of positions from 1982 to 1996. Most recently, he was president of Turner International Inc., supervising its global operations, including 13 sales offices with more than 300 employees worldwide.

Shiron

Addition to Team

Shiron Satellite Communications Ltd. has appointed Henri Telner as the company's new CEO. He will join the management team of Shiron with Dr. Shaul Laufer as president and R. Arie Reichman as chief technology officer. Telner has led companies such as Pegasus Technologies Ltd., Galcom Networking Ltd., ACE400 Communications Ltd. and Koor France SARL.

Starburst

Senior Executives

Starburst Communications appointed two new executives with more than 30 years of combined experience in international business and marketing. The company named Richard Ford as its new director of international sales and Carol Schmitt as vice president of business development.

Ford, a 20-year veteran of high-tech marketing, joins Starburst from the carrier systems division of 3Com, formerly U.S. Robotics, where he managed all aspects of international product marketing and initiated high-level sales.

Schmitt has led product marketing, executive-level business strategy, and partner and channel programs for companies such as Sterling Commerce and S2 Systems, an independent software subsidiary of Stratus Computer.

Ford will oversee Starburst's international sales and marketing initiatives, while Schmitt will be in charge of business development and global business partnerships.

Wold International — Appointments in Latin America

Irene M. de Escardó was elevated to president of Wold Internacional S.A., the company's Latin American subsidiary, based in Buenos Aires. She is responsible for strategic direction, future expansion and business development for Latin America and secondarily for North America, Europe and Asia.

F. Julian Escardó was named manager of Wold International's Latin America business unit. He is responsible for customer service, operations management and sales in Latin America.

Contracts

BT

Partners with Wold

British Telecom and Wold International, through its Argentine-licensed subsidiary Wold Internacional S.A., are forming a strategic partnership to provide transmission services to the Latin America market.

The agreement will include providing BT's new earth station trucks to Argentina and co-marketing Wold's lease of a transponder on Intelsat 806, known as one of Latin America's video hot birds. As part of the deal, Wold will have access to BT's facilities in North America, including Brightstar satellite transmission services.

Comsat

Signs Contract with Sky Station

Comsat Laboratories won a $3.5 million contract to provide communications networking services to Sky Station International Inc.

Sky Station International is developing a proprietary telecommunications system to transmit Internet, video and other high-speed data services using helium-filled platforms in the stratosphere 21 kilometers above the world's major metropolitan regions.

Comsat joins Sky Station's industrial team as communications system integrator, responsible for developing specifications for the key communications systems. Comsat also will coordinate the design, development and deployment of the communications equipment used onboard the platforms, as well as the gateway earth stations and user terminals.

Electromagnetic

New Transponders

Electromagnetic Sciences Inc.'s Canadian unit of its space division, CAL Space Systems, has received an order from Alliedsignal Defense and Space Systems of Teterboro, NJ, to provide five fourth-generation compatible TDRSS, TT&C (telemetry, tracking and control) transponders for the Kistler Aerospace reusable launch vehicle program.

Kistler Aerospace is developing a two-stage reusable launch vehicle with a first launch scheduled for the fourth quarter of 1998 from Woomera, Australia. Each of the

K1 launch vehicles is designed for 100 launches. Operational launches for this system are scheduled for mid-1999.

International Datacasting
Superflex for Kingston

International Datacasting Corp. (IDC) announced that following a month of successful technical trials, Kingston Satellite Services (KSS) of Bedford, United Kingdom, has purchased a DVB-Superflex system to implement Internet and multimedia broadcast services into Europe, Russia and the Middle East. The service will include IP data push configurations and file caching applications.

Integral — Receives Award

Integral Systems Inc. (ISI) was awarded a two-year, $2.4 million subcontract to support NOAA's (National Oceanic and Atmospheric Administration) satellite control center workstation replacement effort.

Integral Systems will subcontract through RETI (Raytheon Electronic Technologies Inc.) on the Defense Microelectronics Activity ATSP (Advanced Technologies Support Program). The program incorporates ISI's Epoch 2000 satellite control center technology into the existing NOAA control center to provide modern, state-of-the-art operations capabilities for the GOES, POES and DMSP satellite programs.

Integral Systems will provide operations personnel for three different satellite programs with new state-of-the-art workstation software. Integral will design the system, develop the software and integrate the new workstations into the existing satellite control centers for NOAA's Polar Acquisition and Control System used to operate the Air Force meteorological satellites.

Tadiran
Contract Extension With Extel

Tadiran Scopus Ltd. and Extel Engineering signed a further extension of their contract for the supply of Codico equipment with Pramer Argentina. The first $1 million contract was awarded in November 1997 for Tadiran Scopus to supply its Codico line for a large satellite-operated, digital-transmission system.

The third extension is for the provision of Codico equipment for an important expansion of Pramer's digital transmission network via satellite. This contract, like the original, is in the turnkey project format and includes several E110 encoders in addition to hundreds of IRD-250 integrated receiver decoders.

DirecTV
Signs Agreement With Thomson

DirecTV Inc., a unit of Hughes Electronics Corp., and Thomson Multimedia have signed a wide-ranging and long-term cooperation agreement. The memorandum of understanding commits DirecTV and Thomson to the joint development and distribution of advanced direct broadcast satellite televisions. The advanced devices will be released under respective brands Thomson and DirecTV. They agree to work together to accelerate the deployment of digital terrestrial television and related digital services.

Divicom
Wins DirecTV Contract

Divicom Inc., a provider of systems for digital television, has signed an agreement to supply DirecTV with compression equipment for its new Los Angeles Broadcast Center. As part of the agreement, Divicom and DirecTV are working together to develop a complete uplink signal processing system to support the DirecTV programming service.

Divicom will supply products from its Mediaview T family of program encoders, the Medianode T multiplexer and the MPEG Media Toolkit T. DirecTV also will be using Divitrack T, the statistical multiplexing feature of the Mediaview MV40 encoder. In addition, Divicom is responsible for the integration of the Uplink Signal Processing System.

Media4
Contract With IT

Media4 Inc. signed a contract with I.T. Interface-Telemarket, based in Rome, a provider of the TV Files service in association with the EBU (European Broadcasting Union).

Under the terms of the agreement, Media4 will supply the complete TV Files system providing delivery of video streams

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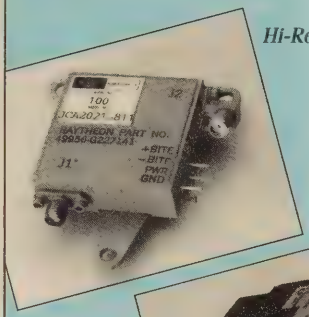
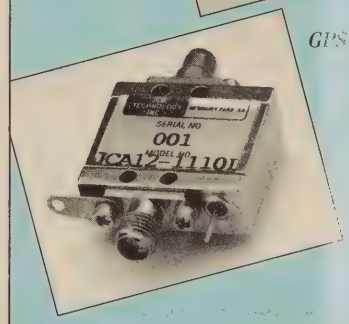


Commercial

GPS



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JCA812-F01	8.0-12.0	22	2.5	$495
JCA1218-F01	12.0-18.0	22	3.5	$495

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Circle Reader Response 7

and multimedia files via satellite to an ICE BoxT, which receives the video streams and program clips for viewing by the TV program buyer. Media4's ICE Box product is based on the Intel processor and uses Media4's Internet Commerce Engine (ICE), which combines DVB data broadcasting, IP multicasting and MPEG video processing to provide an end-to-end multimedia product delivery solution.

SERVICES

AGI
Adopts Licensing Program

Analytical Graphics Inc. adopted both a short-term licensing and a lease-purchase program in an effort to make its Satellite Took Kit (STK) software suite available to customers who need specific programs on a mission-by-mission basis.

Under the new programs, the STK family of products may be rented from AGI for periods up to a year. The lease-purchase plan can run for periods of up to 60 months with the customer having the option to buy the software after the lease has expired. The entire STK family of add-on products (23 modules) is available to rent or lease.

Alliant Techsystems — New Launch Facility

Alliant Techsystems opened a new facility at the Tri-State Commerce Park in Iuka, MS. More than 100 representatives from Iuka, Tishomingo County, the state of Mississippi and The Boeing Co. attended the inaugural ceremony.

Alliant's Space and Strategic Systems Group will manufacture composite structures for the new Boeing Delta 4 family of space launch vehicles at the new plant and then ship the structures by barge to the Delta 4 factory in Decatur, AL. The first structures are scheduled for delivery in the second quarter of 1999. The Iuka plant is expected to create approximately 100 new jobs, mostly filled by personnel from the area.

Anacom
New Look

Anacom Inc. has a new look for its company Web site. (http://www.anacominc.com) The company has the same news and information, but according to Anacom the redesigned Web site is easier to navigate by product frequency and has helpful new features, such as downloadable specifications and photos of the product line.

BT Broadcast
DC Teleport

BT Broadcast Services, a unit of British Telecom that transmits news, sports and entertainment programs around the world, formally unveiled its first North American headquarters in Washington, DC. The downtown facility is aimed at offering a complete range of broadcast transmission solutions with connectivity via satellite, microwave and fiber throughout the world.

British Telecom spent close to $10 million to revamp and expand its Washington teleport.

The enhanced service is part of an international upgrade that already has led to improvements in the company's Paris operations, and BT plans to do likewise in Miami, New York and Los Angeles.

BT
Launches Satlink Asia

BT Global Satellite Solutions launched Satlink Asia, a new service providing international voice, data and Internet network access within the Asia Pacific. It is the first pan-Asian satellite service offered by BT.

Satlink Asia will be available starting in Hong Kong, Taiwan, China, Indonesia, Sri Lanka and Thailand. It will be managed and supported locally by BT's global strategic markets division.

DCI
Video Streaming

Diversified Communications Inc. is offering a video streaming service over the Internet. The service will complement the existing teleport services and offer a new dimension in communications capabilities. Video streaming provides the capability for clients to have their video content streamed over the Internet as a standalone service or to extend the reach of a satellite feed.

Echostar/Loral Skynet
New Channel Package

Loral Skynet and Echostar Communications Corp. released pricing and programming packages for the recently announced direct-to-home (DTH) satellite television servi offered in conjunction with Loral Skyne transportation and distribution service. Bo services will be available on Loral Skyne Telstar 5 satellite located at 97°W.

In June Loral Skynet and Echostar agre in principle to form a strategic alliance to of a host of new digital-based services to cal operators, programmers and DTH co sumers. The alliance created two new servic Echostar's Skyvista DTH package and Skyr Direct, Loral Skynet's transmission and dist bution service. The services are offered to pr grammers and other niche service provide such as international channels, specializ channels, distance-learning services and cc porate business television networks.

Foxcom
Splits Into Two Firms

Foxcom, a leading fiber optic communic tions equipment provider, has split into tv firms: Foxcom and Foxcom Wireless. Ea firm will focus on its core competencies the multi-billion-dollar broadband ar mobile communications markets.

Foxcom is focusing on broadband cor munications infrastructure to the multi-b lion-dollar multiple dwelling unit (MDU) se tor with its point to multipoint SDTV systen

In related news, Star Choice, a direct-t home digital satellite service provider Canada, will connect multiple dwelli units subscribers in Canada using Foxcor SDTV fiber optic distribution system. T Foxcom-Star Choice deal is valued at $2 $3 million over the next 12 months.

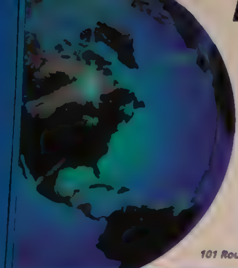
TECHNOLOGY

Digital Voice Systems
AMBE-1000 in Japan

Digital Voice Systems Inc. selected Interr Inc. to distribute the AMBE-1000 vocod chip in Japan. A technology distributor ar representative, Internix will be able to provi local support and service for the product.

The AMBE-1000 is a flexible, low data r vocoder available as a single chip solution th provides near toll quality speech. Operating data rates from 2.4 to 9.6 kbps and scaleable 50 bit increments, this voice codec is suited f a variety of voice applications.

The AMBE-1000 is a real-time, fu duplex implementation of DVSI's sta dard-setting AMBE speech compressi system. (*Digital Voice Systems, One Van Graaff, Burlington, MA 01803; Tel: 781/27*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- Ku-band
- C-, Ku-band
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- C-, S-band
- Ka-, Ku-band
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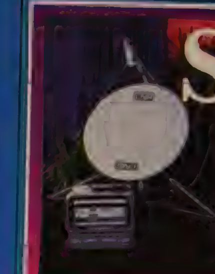
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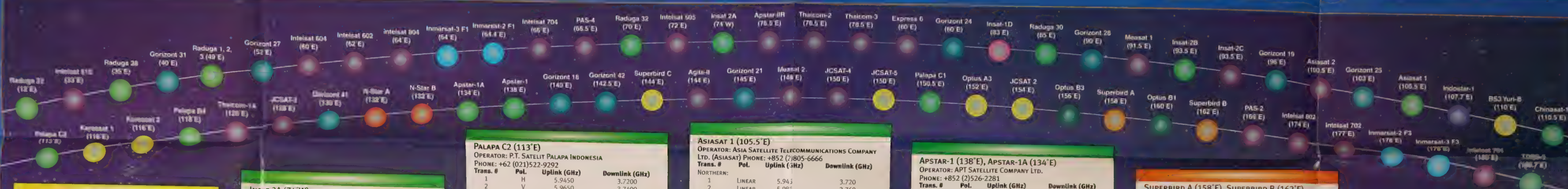

Koreasat 1 (116°E), Koreasat 2 (116°E)
Operator: Ministry of Communications (Korea)
Phone: +82 42-860-4630

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	V	5.9350	3.7100
2	H	5.9650	3.7400
3	H	5.9850	3.7600
5	V	6.0250	3.8000
6	V	6.0450	3.8200
7	V	6.0850	3.8600
8	H	6.0950	3.8700
9	V	6.1050	3.8800
10	H	6.1250	3.9000

Chinasat-1 (110.5°E)
Operator: Ministry of Posts and Telecommunications (China) Phone: +86 (1)601-1250

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
2	H	5.9650	3.7400
3	H	5.9850	3.7600
5	V	6.0250	3.8000

PAS-2 (169°E)
Operator: Panamsat Corporation Phone: (203)622-6664

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
C-band:			
1	V	5.955	3.730
2	H	5.955	3.730
3	V	6.015	3.790
4	H	6.015	3.790
5	V	6.075	3.850
6	H	6.075	3.850
7	V	6.140	3.915
8	H	6.140	3.915
9	V	6.205	3.980
10	H	6.205	3.980
11	V	6.265	4.040
12	H	6.265	4.040
13	V	6.325	4.100
14	H	6.325	4.100
15	V	6.390	4.165
16	H	6.390	4.165
Ku-band:			
1	H	14.029	12.281
2	V	14.029	12.281
3	H	14.089	12.341
4	V	14.089	12.341
5	H	14.149	12.401
6	V	14.149	12.401
7	H	14.214	12.466
8	V	14.214	12.466
9	H	14.279	12.531
10	V	14.279	12.531
11	H	14.339	12.591
12	V	14.339	12.591
13	H	14.399	12.651
14	V	14.399	12.651
15	H	14.464	12.716
16	V	14.464	12.716

Palapa C1 (150.5°E)
Operator: P.T. Satelit Palapa Indonesia
Phone: +62 (021)522-9292

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	V	14.0160	12.2680
2	H	14.0310	12.2830
3	V	14.0460	12.2980
4	H	14.0610	12.3130
5	V	14.0760	12.3280
6	H	14.0910	12.3430
7	V	14.1060	12.3580
8	H	14.1210	12.3730
9	V	14.1360	12.3880

Insat 2A (74°W)
Operator: Indian Department of Space
Phone: +91 (8)033-34474

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
[illegible]	Linear	5.950	3.725
[illegible]	Linear	5.990	3.765
[illegible]	Linear	6.030	3.805
[illegible]	Linear	6.070	3.845
[illegible]	Linear	6.110	3.885
6	Linear	6.150	3.925
7	Linear	6.190	3.965
8	Linear	6.230	4.005
9	Linear	6.270	4.045
[illegible]	Linear	6.310	4.085
[illegible]	Linear	6.350	4.125
[illegible]	Linear	6.755	4.165
[illegible]	Linear	6.755	4.530
[illegible]	Linear	6.795	4.570
[illegible]	Linear	6.835	4.610
[illegible]	Linear	6.875	4.650
[illegible]	Linear	6.915	4.690
[illegible]	Linear	6.955	4.730
[illegible]	LHCP	5.870	2.570
[illegible]	LHCP	5.910	2.610

Insat 2B (93.5°E)
Operator: Indian Department of Space
Phone: +91 (8)033-34474

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
[illegible]	Linear	5.970	3.745
[illegible]	Linear	6.010	3.785
[illegible]	Linear	6.050	3.825
[illegible]	Linear	6.090	3.865
[illegible]	Linear	6.130	3.905
[illegible]	Linear	6.170	3.945
[illegible]	Linear	6.210	3.985
[illegible]	Linear	6.250	4.025
[illegible]	Linear	6.290	4.065
[illegible]	Linear	6.330	4.105
[illegible]	Linear	6.365	4.140
[illegible]	Linear	6.395	4.170
[illegible]	Linear	6.755	4.530
[illegible]	Linear	6.795	4.570
[illegible]	Linear	6.835	4.610
[illegible]	Linear	6.875	4.650
[illegible]	Linear	6.915	4.690
[illegible]	Linear	6.955	4.730
[illegible]	LHCP	5.870	2.570
[illegible]	LHCP	5.910	2.610

Agila II (144°E)
Operator: Mabuhay Philippines Satellite Corporation
Phone: +63 2-811-0983

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
Standard C-band:			
1	V	5.945	3.720
2	H	5.965	3.740
3	V	5.985	3.760
4	H	6.005	3.780
5	V	6.025	3.800
6	H	6.045	3.820
7	V	6.065	3.840
8	H	6.085	3.860
9	V	6.105	3.880
[illegible]	H	6.125	3.900
[illegible]	V	6.145	3.920
[illegible]	H	6.165	3.940
[illegible]	V	6.185	3.960
[illegible]	H	6.205	3.980
[illegible]	V	6.225	4.000
[illegible]	H	6.245	4.020
[illegible]	V	6.265	4.040
18	H	6.285	4.060
[illegible]	V	6.305	4.080
[illegible]	H	6.325	4.100
[illegible]	V	6.345	4.120
[illegible]	H	6.365	4.140
23	V	6.385	4.160
24	H	6.402	4.177
Extended C-band:			
25	V	6.605	3.580
26	H	6.625	3.600
27	V	6.645	3.620
[illegible]	H	6.665	3.640
[illegible]	[illegible]	6.685	3.660
[illegible]	[illegible]	6.705	3.680
Ku-band:			
[illegible]	H	14.039	12.221
[illegible]	H	14.079	12.261
[illegible]	H	14.119	12.301
[illegible]	H	14.159	12.341
5	H	14.199	12.381
6	H	14.239	14.421
7	H	14.279	14.461
8	H	14.319	12.501
9	H	14.359	12.541
10	H	14.399	12.581
11	H	14.439	12.621
12	H	14.479	12.661
13	V	14.039	12.221
14	V	14.079	12.261
15	V	14.119	12.301
16	V	14.159	12.341
17	V	14.199	12.381
18	V	14.239	12.421
19	V	14.279	12.461
20	V	14.319	12.501
21	V	14.359	12.541
22	V	14.399	12.581
23	V	14.439	12.621
24	V	14.479	12.661

BS3 Yuri-B (110°E)
Operator: TAO Phone: +81 (3)3769-6811

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
6	H	6.0450	3.8200
7	V	6.0650	3.8400
8	H	6.0850	3.8600
9	V	6.1050	3.8800
10	H	6.1250	3.9000

Palapa C2 (113°E)
Operator: P.T. Satelit Palapa Indonesia
Phone: +62 (021)522-9292

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	H	5.9450	3.7200
2	V	5.9650	3.7400
3	H	5.9850	3.7600
4	V	6.0050	3.7800
5	H	6.0250	3.8000
6	V	6.0450	3.8200
7	H	6.0650	3.8400
8	V	6.0850	3.8600
9	H	6.1050	3.8800
10	V	6.1250	3.9000
11	H	6.1450	3.9200
12	V	6.1650	3.9400
13	H	6.1850	3.9600
14	V	6.2050	3.9800
15	H	6.2250	4.0000
16	V	6.2425	4.0200
17	H	6.2625	4.0400
18	V	6.2825	4.0600
19	H	6.3050	4.0800
20	V	6.3250	4.1000
21	H	6.3450	4.1200
22	V	6.3650	4.1400
23	H	6.3850	4.1600
24	V	6.4050	4.1800
25	H	6.4250	4.2000
26	V	6.4450	4.2200
27	H	6.4650	4.2400
28	V	6.4850	4.2600
29	H	6.5050	4.2800
30	V	6.5250	4.3000
31	H	6.5450	4.3200
32	V	6.5650	4.3400

Superbird C (144°E)
Operator: Space Communications Corporation (SCC)
Phone: +81 (3)5462-1370

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	V	14.050	12.320
2	V	14.110	12.380
3	V	14.160	12.430
4	V	14.200	12.470
5	V	14.253	12.523
6	V	14.283	12.553
7	V	14.313	12.583
8	V	14.343	12.613
9	V	14.373	12.643
10	V	14.403	12.673
11	V	14.433	12.703
12	V	14.463	12.733
13	H	14.050	12.320
14	H	14.110	12.380
15	H	14.160	12.430
16	H	14.200	12.470
17	H	14.238	12.508
18	H	14.268	12.538
19	H	14.298	12.568
20	H	14.328	12.598
21	H	14.358	12.628
22	H	14.388	12.658
23	H	14.418	12.688
24	H	14.448	12.718

Optus A3 (152°E)
Operator: Optus Communications Pty. Ltd.
Phone: +61 (2)342-7800

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	V	14.025	12.277
2	V	14.089	12.341
3	V	14.153	12.405
4	V	14.217	12.469
5	V	14.281	12.533
6	V	14.345	12.597
7	V	14.409	12.661
8	V	14.473	12.725
9	H	14.057	12.309
10	H	14.121	12.373
11	H	14.185	12.437
12	H	14.249	12.501
13	H	14.313	12.565
14	H	14.377	12.629
15	H	14.441	12.693

Measat 1 (91.5°E)
Operator: Binariang Satellite Systems Sdn Bhd
Phone: +60 (3)380-7000

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	V up, H down	5.945	3.720
2	V up, H down	5.985	3.760
3	V up, H down	6.025	3.800
4	V up, H down	6.065	3.840
5	V up, H down	6.105	3.880
6	V up, H down	6.145	3.920
7	V up, H down	6.185	3.960
8	V up, H down	6.225	4.000
9	V up, H down	6.265	4.040
10	V up, H down	6.305	4.080
11	V up, H down	6.345	4.120
12	V up, H down	6.385	4.160
Malaysia and Philippines:			
M1/P1	V	14.032	10.982
M2/P2	V	14.094	11.044
M3	V	14.156	11.106
M4	V	14.218	11.168
India:			
I1	V	13.784	12.284
I2	V	13.846	12.346

Asiasat 1 (105.5°E)
Operator: Asia Satellite Telecommunications Company Ltd. (Asiasat) Phone: +852 (2)805-6666

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
Northern:			
1	Linear	5.945	3.720
2	Linear	5.985	3.760
3	Linear	6.025	3.800
4	Linear	6.065	3.840
5	Linear	6.105	3.880
6	Linear	6.145	3.920
7	Linear	6.185	3.960
8	Linear	6.225	4.000
9	Linear	6.265	4.040
10	Linear	6.305	4.080
11	Linear	6.345	4.120
12	Linear	6.385	4.160
Southern:			
1	Linear	5.965	3.740
2	Linear	6.005	3.780
3	Linear	6.045	3.820
4	Linear	6.085	3.860
5	Linear	6.125	3.900
6	Linear	6.165	3.940
7	Linear	6.205	3.980
8	Linear	6.245	4.020
9	Linear	6.285	4.060
10	Linear	6.325	4.100
11	Linear	6.365	4.140
12	Linear	6.405	4.180

Insat-2C (93.5°E)
Operator: Indian Department of Space
Phone: +91 (8)033-34474

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	Linear	5.950	3.725
2	Linear	5.990	3.765
3	Linear	6.030	3.805
4	Linear	6.070	3.845
5	Linear	6.110	3.885
6	Linear	6.150	3.925
7	Linear	6.190	3.965
8	Linear	6.230	4.005
9	Linear	6.270	4.045
10	Linear	6.310	4.085
11	Linear	6.350	4.125
12	Linear	6.39[illegible]	4.165
13	Linear	6.75[illegible]	4.530
14	Linear	6.795	4.570
15	Linear	6.835	4.610
16	Linear	6.875	4.650
17	Linear	6.915	4.690
18	Linear	6.955	4.730
19	Linear	6.460	2.510
19	Linear	2.680	3.690
20	Linear	5.910	2.610
21	Linear	14.2925	11.4925
22	Linear	14.375	11.575
23	Linear	14.45[illegible]	11.655

TDRS-5 (185.7°E)
Operator: Columbia Communications Corporation
Phone: (301)907-8800; (800)418-3777

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	Linear	5.945	3.720.2
2	Linear	5.985	3.760.2
3	Linear	6.025	3.800.2
4	Linear	6.065	3.840.2
5	Linear	6.105	3.880.2
6	Linear	6.145	3.920.2
7	Linear	6.185	3.960.2
8	Linear	6.225	4.000.2
9	Linear	6.265	4.040.2
10	Linear	6.305	4.080.2
11	Linear	6.345	4.120.2
12	Linear	6.385	4.160.2

Raduga 22 (12°E), Raduga 28 (35°E), Raduga 1, 2, 3 (49°E), Raduga 32 (70°E), Raduga 30 (85°E)
Operator: Ministry for Postal Services and Telecommunications (Russia) Phone: +7 (095)925 5108

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	RH	5.750	3.425
2	RH	5.800	3.475
3	RH	5.850	3.525
4	RH	5.900	3.575
5	RH	5.950	3.625
6	RH	6.000	3.675
7	RH	6.050	3.725
8	RH	6.100	3.775
9	RH	6.150	3.825
10	RH	6.200	3.875
11	RH	6.250	3.925

Gorizont 31 (40°E), Gorizont 27 (52°E), Gorizont 24 (80°E), Gorizont 28 (90°E), Gorizont 19 (96°E), Gorizont 25 (103°E), Gorizont 41 (130°E), Gorizont 18 (140°E), Gorizont 42 (142.5°E), Gorizont 21 (145°E)
Operator: Ministry for Postal Services and Telecommunications (Russia) Phone: +7 (095)925 5108

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
6[-1]	RH	6.000	3.675
7[1]	RH	6.050	3.725
8[4]	RH	6.100	3.775
9[6]	RH	6.150	3.825
10[9]	RH	6.200	3.875
11[11]	RH	6.250	3.925
Loutch	RH		11.541

Apstar-1 (138°E), Apstar-1A (134°E)
Operator: APT Satellite Company Ltd.
Phone: +852 (2)526-2281

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1A	Linear	5.885	3.660
1B	Linear	5.885	3.660
2A	Linear	5.965	3.740
2B	Linear	5.985	3.760
3A	Linear	6.025	3.800
3B	Linear	6.045	3.820
4A	Linear	6.065	3.840
4B	Linear	6.085	3.860
5A	Linear	6.105	3.880
5B	Linear	6.125	3.900
6A	Linear	6.145	3.920
6B	Linear	6.165	3.940
7A	Linear	6.185	3.960
7B	Linear	6.205	3.980
8A	Linear	6.225	4.000
8B	Linear	6.245	4.020
9A	Linear	6.265	4.040
9B	Linear	6.285	4.060
10A	Linear	6.305	4.080
10B	Linear	6.325	4.100
11A	Linear	6.345	4.120
11B	Linear	6.365	4.140
12A	Linear	6.385	4.160
12B	Linear	6.405	4.180

Thaicom-2 (78.5°E)
Operator: Shinawatra Satellite Public Company Ltd.
Phone: +66 (2)591-0736 through 0749

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	H	5.9130	2.6130
2	H	5.9900	3.7650
3	H	6.0300	3.8050
4	H	6.0700	3.8450
5	H	6.1100	3.8850
6	H	6.1500	3.9250
7	H	6.1900	3.9650
9	H	6.2700	4.0450
C1	V	5.9450	3.7200
C2	V	5.9850	3.7600
C3	V	6.0250	3.8000
C4	V	6.0650	3.8400
C5	V	6.1050	3.8800
C6	V	6.1450	3.9200
C7	V	6.1850	3.9600
C8	V	6.2250	4.0000
C9	H	6.2650	4.0400
C10	H	6.3050	4.0800
C11	H	6.3450	4.1200
C12	V	6.3850	4.1600
K1	V	14.3429	12.5949
K2	V	14.4055	12.6575
K3	V	14.4681	12.7201

Optus B1 (160°E), Optus B3 (156°E)
Operator: Optus Communications Pty. Ltd.
Phone: +61 (2)342-7800

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	V	14.0299	12.2819
2	V	14.0925	12.3445
3	V	14.1551	12.4071
4	V	14.2177	12.4697
5	V	14.2803	12.5323
6	V	14.3429	12.5949
7	V	14.4055	12.6575
8	V	14.4681	12.7201
9	H	14.0612	12.3132
10	H	14.1238	12.3758
11	H	14.1864	12.4384
12	H	14.2490	12.5010
13	H	14.3116	12.5636
14	H	14.3742	12.6262
15	H	14.4368	12.6888

Asiasat 2 (100.5°E)
Operator: Asia Satellite Telecommunications Company Ltd. (Asiasat) Phone: +852 (2)805-6666

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1A	H up, V down	5.885	3.660
1B	V up, H down	5.868	3.640
2A	H up, V down	5.925	3.700
2B	V up, H down	5.905	3.680
3A	H up, V down	5.965	3.740
3B	V up, H down	5.945	3.720
4A	H up, V down	6.005	3.780
4B	V up, H down	5.985	3.760
5A	H up, V down	6.045	3.820
5B	V up, H down	6.025	3.800
6A	H up, V down	6.085	3.860
6B	V up, H down	6.065	3.840
7A	H up, V down	6.125	3.900
7B	V up, H down	6.105	3.880
8A	H up, V down	6.165	3.940
8B	V up, H down	6.145	3.920
9A	H up, V down	6.205	3.980
9B	V up, H down	6.185	3.960
10A	H up, V down	6.245	4.020
10B	V up, H down	6.225	4.000
11A	H up, V down	6.305	4.080
11B	V up, H down	6.285	4.060
12A	H up, V down	6.385	4.160
12B	H up, V down	6.365	4.140

Measat 2 (148 E)
Operator: Binariang Satellite Systems Sdn Bhd
Phone: +60 (3)380-7000

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
C-band:			
1C	*	5.965	3.740
2C	*	6.045	3.820
3C	*	6.125	3.900
1	*	6.205	3.980
2	*	6.285	4.060
3	*	6.365	4.140
Ku-band: Philippines, Indonesia, West Malaysia, Vietnam, Eastern Australia, and Taiwan			
up to 9	H	13.750-14.500	10.950-12.700

[*Uplink: Horizontal (East Asia), Vertical (Eastern Australia and Hawaii); Downlink: Vertical]

N-Star A (132°E), N-Star B (132 E): For technical information on N-Star, contact Nippon Telegraph and Telephone Corporation (NTT) at +81 (3)5563-7252.

Indostar-1 (107.7°E): For technical information on Indostar, contact P.T. Mediacitra Indostar at +62 21-390-9211.

Palapa B4 (118°E): For technical information on Palapa, contact PT Satelit Palapa Indonesia at +62 (021)522-9292.

Inmarsat-2 F1 (64.4°E), Inmarsat-2 F3 (178°E), Inmarsat-3 F1 (64°E) Inmarsat-3 F3 (178°E): For technical information on Inmarsat-2 F1, Inmarsat-2 F3, Inmarsat-3 F1, or Inmarsat-3 F3, contact the International Mobile Satellite Organization at +44 171-728-1000.

JCSAT-3 (128°E), JCSAT-4 (150°E), JCSAT-5 (150°E): For technical information on JCSAT-3, JCSAT-4 or JCSAT-5, contact Japan Satellite Systems, Inc. (JSAT) at +81 (335)511-7778.

Intelsat 505 (72°E), 510 (33°E), 602 (62°E), 604 (60°E), 701 (180°E), 702 (177°E), 704 (66°E), 802 (174°E), 804 (64°E): For technical information, contact Intelsat (International Telecommunications Satellite Organization) at (202)944-6800.

Thaicom-1A (120°E), Thaicom-3 (78.5°E): For technical information on Thaicom-1A or Thaicom-3, contact Shinawatra Satellite Public Company Ltd. at +66 (2)591-0736 through 0749

Superbird A (158°E), Superbird B (162°E)
Operator: Space Communications Corporation (SCC)
Phone: +81 (3)5462-1370

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	H	14.020	12.290
2	H	14.060	12.330
3	H	14.100	12.370
4	H	14.140	12.410
5	H	14.180	12.450
6	H	14.220	12.490
7	H	14.260	12.530
8	H	14.300	12.570
9	H	14.340	12.610
10	H	14.380	12.650
11	H	14.420	12.690
12	H	14.460	12.730
13	V	14.040	12.310
14	V	14.080	12.350
15	V	14.120	12.390
16	V	14.160	12.430
17	V	14.200	12.470
18	V	14.240	12.510
19	V	14.280	12.550
20	V	14.320	12.590
21	V	14.360	12.630
22	V	14.400	12.670
23	V	14.440	12.710
T1	LHC	27.625	17.825
T2	LHC	27.745	17.945
T3	LHC	27.865	18.065
N1	LHC	28.345	18.545
N2	LHC	28.465	18.665
N3	LHC	28.585	18.785
N4	LHC	28.705	18.905
N5	LHC	28.825	19.025
N6	LHC	28.945	19.145
N7	LHC	29.065	19.265

JCSAT 2 (154°E)
Operator: Japan Satellite Systems, Inc. (JSAT)
Phone: +81 (335)511-7778

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
9	V	14.1360	12.3880
10	H	14.1510	12.4030
11	V	14.1660	12.4180
12	H	14.1810	12.4330
17	V	14.2560	12.5080
19	H	14.2860	12.5380
20	H	14.3010	12.5530
26	H	14.3910	12.6430
27	V	14.4060	12.6580
28	H	14.4210	12.6730
29	V	14.4360	12.6880
30	H	14.4510	12.7030
31	V	14.4660	12.7180
32	H	14.4810	12.7330
1	V	14.0299	12.2819
9	H	14.0612	12.3131
10	H	14.1238	12.3758
2	V	14.1530	12.4050
3	V	14.1551	12.4071
11	H	14.1850	12.4370
4	V	14.2170	12.4690
12	H	14.2490	12.5010
5	V	14.2810	12.5330
23	V	14.3460	12.5980
24	V	14.3610	12.6130
25	V	14.3760	12.6280
26	H	14.3910	12.6430
27	V	14.4060	12.6580
28	H	14.4210	12.6730
29	V	14.4360	12.6880
30	H	14.4510	12.7030
31	V	14.4660	12.7180
32	H	14.4810	12.7330

Apstar-IIR (76.5°E)
Operator: APT Satellite Company Ltd.
Phone: +852 (2)526-2281

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
C-band:			
1A	Linear	5.868	3.643
1B	Linear	5.885	3.660
2A	Linear	5.905	3.680
2B	Linear	5.925	3.700
3A	Linear	5.945	3.720
3B	Linear	5.965	3.740
4A	Linear	5.985	3.760
4B	Linear	6.005	3.780
5A	Linear	6.025	3.800
5B	Linear	6.045	3.820
6A	Linear	6.065	3.840
6B	Linear	6.085	3.860
7A	Linear	6.105	3.880
7B	Linear	6.125	3.900
8A	Linear	6.145	3.920
8B	Linear	6.165	3.940
9A	Linear	6.185	3.960
9B	Linear	6.205	3.980
10A	Linear	6.225	4.000
10B	Linear	6.245	4.020
11A	Linear	6.265	4.040
11B	Linear	6.285	4.060
12A	Linear	6.305	4.080
12B	Linear	6.325	4.100
13A	Linear	6.345	4.120
13B	Linear	6.365	4.140
14A	Linear	6.385	4.160
14B	Linear	6.405	4.180
Ku-band:			
1A	Linear	14.022	12.272
1B	Linear	14.0435	12.2935
2A	Linear	14.074	12.324
2B	Linear	14.1045	12.3545
3A	Linear	14.1355	12.385
3B	Linear	14.1655	12.4155
4A	Linear	14.196	12.446
4B	Linear	14.2265	12.4765
5A	Linear	14.257	12.507
5B	Linear	14.2875	12.5375
6A	Linear	14.318	12.568
6B	Linear	14.3485	12.5985
7A	Linear	14.379	12.629
7B	Linear	14.4095	12.6595
8A	Linear	14.440	12.690
8B	Linear	14.4705	12.7205

Express 6 (80 E)
Operator: Intersputnik Phone: +7 (095)244 0333

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
7	RHCP	6.050	3.7250
8	RHCP	6.100	3.7750
9	RHCP	6.150	3.825
10	RHCP	6.200	3.875
11	RHCP	6.250	3.925
14	RHCP	6.300	3.975
15	RHCP	6.350	4.025
16	RHCP	6.400	4.075
17	RHCP	[illegible]	[illegible]

PAS-4 (68.5 E)
Operator: Panamsat Corporation Phone: (203)622-6664

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
C-band:			
1	H	5.955	3.730
2	V	5.955	3.730
3	H	6.015	3.790
4	V	6.015	3.790
5	H	6.075	3.850
6	V	6.075	3.850
7	H	6.140	3.915
8	V	6.140	3.915
9	H	6.205	3.980
10	V	6.205	3.980
11	H	6.265	4.040
12	V	6.265	4.040
13	H	6.325	4.100
14	V	6.325	4.100
15	H	6.390	4.165
16	V	6.390	4.165
Ku-band:			
1	H	14.029	12.531
[illegible]	"	[illegible]	[illegible]
3	"	14.149	[illegible]
4	H	14.214	12.716
5	V	14.279	12.531
6	V	14.339	12.591
7	V	14.399	12.651
8	V	14.464	12.716
9	V	14.014	12.266
10	H	14.044	12.296
11	V	14.074	12.326
12	H	14.104	12.356
13	V	14.134	12.386
14	H	14.164	12.416
15	V	14.199	12.451
16	H	14.229	12.481
17	H	14.264	11.464
18	H	14.294	12.546
19	H	14.324	11.524
20	H	14.354	12.606
21	H	14.384	11.584
22	H	14.414	12.666
23	H	14.449	11.649
24	H	[illegible]	[illegible]

Insat-1D (83°E)
Operator: Indian Department of Space
Phone: +91 (8)033-34474

Trans. #	Pol.	Uplink (GHz)	Downlink (GHz)
1	Linear	5.955	3.730
2	Linear	5.995	3.770
3	Linear	6.035	3.810
4	Linear	6.075	3.850
5	Linear	6.115	3.890
6	Linear	6.155	3.930
7	Linear	6.195	3.970
8	Linear	6.235	4.010
9	Linear	6.285	4.060
10	Linear	6.325	4.100
11	Linear	6.365	4.140
12	Linear	6.405	4.180
S1	LHCP	5.875	2.575
S2	LHCP	[illegible]	[illegible]

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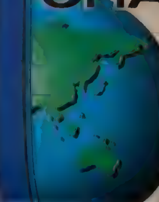
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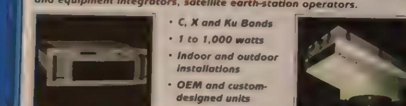
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Circle Reader Response 200

JCA

New Product

JCA Technology released its new JCA218 series of amplifiers. The JCA218-500 model number provides a gain of 39 min. and a flatness of +/- 2.5 dB max. This unit operates at +10 dBm output power with a maximum noise figure of 5.0 dB. The JCA218-500 runs on +15 VDC at 180 mA nominal. (*JCA Technology, 1090 Avenida Acaso, Camarillo, CA 93012; Tel: 805/445-9888; Fax: 805/987-6990; E-mail: jca@jcatech.com; Web: www.jcatech.com*)

Circle Reader Response 201

NDS

New Digital Encoder

NDS is now shipping its new E5000 range of modular MPEG 2 digital encoders. According to NDS, the new range of features has been developed to deliver the most cost-effective broadcast quality encoders on the market, starting at prices under $35,000. The NDS E5000 range is part of NDS' complete end-to-end solutions for all digital broadcasters, including ATSC HDTV and DVB compliant systems for DTH and DTV broadcast services.

(*NDS, 1 Heathrow Blvd, 286 Bath Road, West Drayton, Middlesex, UB7 0DQ, United Kingdom; Tel: +44/181-476-8000; Fax: +44/181-476-8100*)

Circle Reader Response 202

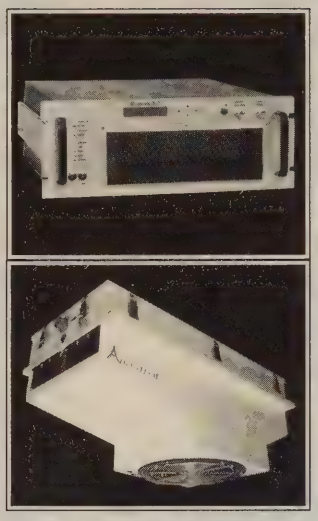
Microwave Filter — New C-band Filter

Microwave Filter Co. has expanded its C-band product line. The model 11870DC is installed between the downconverter and receiver in C-band TVRO systems to remove mild to moderate out of band interference.

The filter passes 950 to 1450 MHz with a loss of 3 dB maximum. Rejection is 20 dB at 850 MHz and 30 dB at 1,550 MHz. The unit has a DC passing spec of 500mA. Impedance is 75 ohms and connectors are type F female. Its dimensions are 4.5" x 2" x1.1".

(*Microwave Filter Co., 6743 Kinne St., East Syracuse, NY 13057; Tel: 800/448-1666; Fax: 800/411-8860; E-mail: mfcsales@microwavefilter.com; Web: www.microwavefilter.com*)

Circle Reader Response 203



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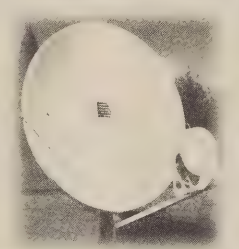

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PETROSAT 98

The Future of Global Oil & Gas Communications

November 17–18,1998 • Houstonian Hotel • Houston, TX

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IS UP IN THE AIR..

Critical information must be shared effectively from wherever petroleum companies have operations. From the deserts of Northern Africa, to sites in South America, from an offshore platform in Southeast Asia to an executive's desk in the United States, timely and exact data needs to be transferred to ensure a project's success.

However, oil and gas companies cannot rely on just phone and fax service. In many areas petroleum businesses are operating, conventional phone service cannot be found. Also, many energy transmissions are so extensive, it would take far too long to send the data via conventional analog or digital phone lines.

Since traditional modes of communication cannot meet the challenges of the global oil and gas industry, more and more companies have turned to communicating via satellite for cost-effective solutions. **PETROSAT 98** is the only conference that gives detailed information on how to turn satellite technology into a reliable and economical solution for the petroleum industry's communication challenges.

WHO SHOULD ATTEND?

PETROSAT 98 will feature an audience composed of executives, operations and technical managers, safety officers, and IT professionals with strategic planning responsibilities from these segments of the energy and satellite industries:

- Production Companies and Operators
- Seismic and Drilling Contractors
- Logging and MWD Contractors
- Geoscientific Applications Software and Hardware Companies
- Construction and Project Management Companies
- Transport & Pipeline Operators
- Systems Integrators and Consultants
- Investment Bankers and Financial Analysts
- Satellite Networks and Facility Providers
- Satellite Operators
- Mobile Satellite Service Providers
- Satellite Transmission Service Providers
- Satellite Equipment Manufacturers

SCHEDULE OF ACTIVITIES

(As of June 3, 1998)

TUESDAY, NOVEMBER 17, 1998

7:00am-5:00pm	Registration
8:00am-9:00am	Continental Breakfast
9:00am-9:15am	Welcome Remarks
9:15am-9:45am	Keynote: David Clementz, President, Chevron Information Technology Group
9:45am-11:00am	Panel Session: "Remote Sensing and Siesmic Acquisition"
11:00am-11:15am	Refreshment Break
11:15am-12:30pm	Panel Session: "Satellite Communications Today and Tomorrow: Evolution of Global Regional GEO Systems"
12:30pm-2:00pm	Luncheon
2:00pm-3:15pm	Panel Session: "Satellite Linked Logging and Drilling"
3:15pm-3:30pm	Refreshment Break
3:30pm-4:00pm	Case Study: "The ARIES Project"
4:00pm-5:15pm	Panel Session: "New Telephony and Messaging Constellations"
5:15pm-6:30pm	Reception

WEDNESDAY, NOVEMBER 18, 1998

7:00am-5:00pm	Registration
8:00am-9:00am	Continental Breakfast
9:00am-9:45am	Keynote: TBD
9:45am-11:00am	Panel Session: "Licensing and Regulatory Issues"
11:00am-11:15am	Refreshment Break
11:15am-12:30pm	Panel Session: "Financing the Global Communications Infrastructure"
12:30pm-2:00pm	Luncheon
2:00pm-3:15pm	Panel Session: "Corporate Systems Connectivity to Offshore and Remote Locations"
3:15pm-3:30pm	Refreshment Break
3:30pm-4:00pm	Case Study: "Geocomputing and Global Communications Networks: Toward the New Era of E&P Productivity"
4:00pm-5:15pm	Panel Session: "The Advent of Wideband Constellations and Their Practical Application in the Energy Industry"

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RECONFERENCE SEMINAR:
SATELLITE BASICS
MONDAY, NOVEMBER 16, 1998

Make the most out of your trip to **PETROSAT 98** and attend the one-day semi-ar, Satellite Basics!

ia Satellite magazine presents the most comprehensive seminar offering a tudy of the technology and issues surrounding satellites. The seminar is eared for professionals at all experience levels. This seminar is an excellent verview for energy executives who want a better understanding of how atellites operate and fit into the global communications structure. Find out ow satellites are used in the telecommunications industry; who is doing vhat in satellite communications; major issues and trends in satellite commu-ications; and what the confusing terms, jargon, buzz words and acronyms ised in satellite business mean. The seminar leader, Dr. Mark Chartrand, rings over a dozen years of experience conducting telecommunications raining programs and conferences.

SATELLITE BASICS PROGRAM

8:00am-9:00am	Registration
9:00am-10:30am	Satellite Business: Applications, Markets and Regulation
10:30am-10:45am	Break
10:45am-12:30pm	Technical Background: The Alphabet Soup Clarified
12:30pm-1:30pm	Luncheon
1:30pm-3:30pm	The Space Segment: What's Up and How It Is Used
3:30pm-3:45pm	Break
3:45pm-5:00pm	The Ground Segment: Down-to-Earth Operations and How It Works

HOTEL INFORMATION

The Houstonian Hotel
111 North Post Oak Lane, Houston, TX 77024
Phone: 713-680-2626, Fax: 713-680-2992

SPECIAL PETROSAT 98 RATES ARE AVAILABLE

SINGLE: $165 DOUBLE: $175

The room rates are subject to prevailing taxes which are currently 17% and subject to change.

Contact the hotel directly and specify PETROSAT 98. These rates are available only until October 23, 1998. The hotel is located approximately 45 minutes from either the Intercontinental Airport or the Hobby Airport.

REGISTRATION FEE

Your One Low Registration Fee Includes:

- ✔ All keynotes, case studies and panel sessions.
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Satellite Basics Seminar $550/person

CANCELLATION POLICY:

Cancellations made less than 30 days prior to the event will be subject to a cancellation fee of $250. All cancellations must be made in writing. Registrants who fail to attend and do not send written notice of cancellation prior to November 13, 1998 will be liable for the full registration fee.

PETROSAT 98 Registration Fax Back Form

❑ **YES!** Please register me for the only conference focused on the future of oil and gas communications!

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4 In Person: After November 12, 1998, do not mail or fax this form; simply present it at the PETROSAT 98 Registration Area at The Houstonian Hotel.

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Channel Master	.channelmasterinc.com
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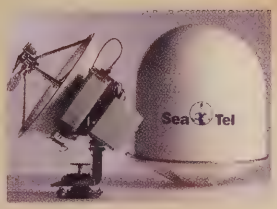

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Wavephore Networks	.wavo.c
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Wireless Resources Inc.	.gowireless.
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WTCom	.wtcom.c
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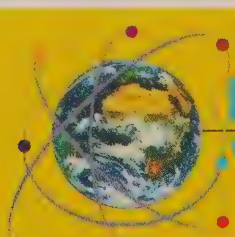

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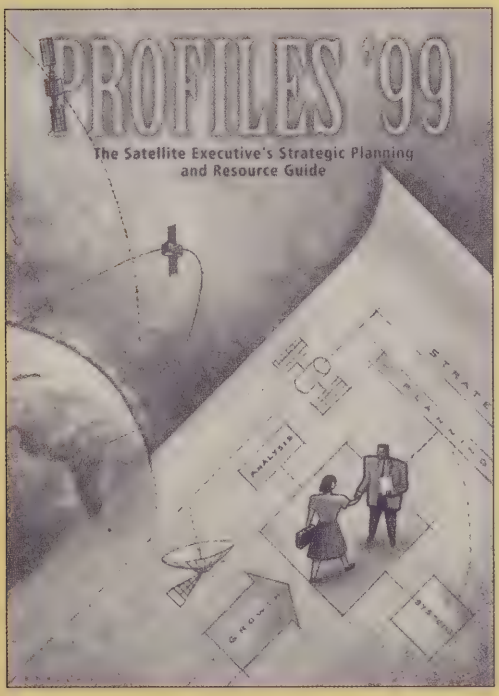

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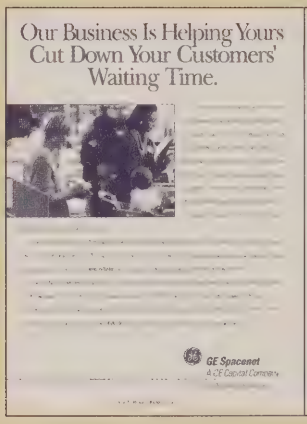

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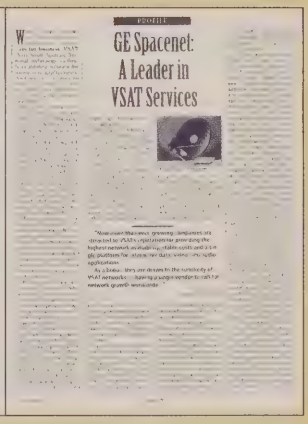

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- ❑ 52. Up to $10,000
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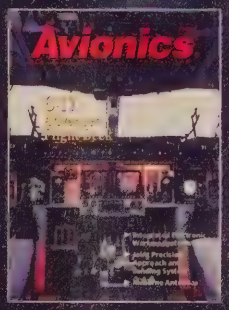

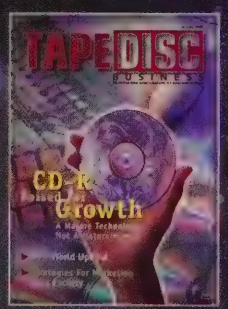

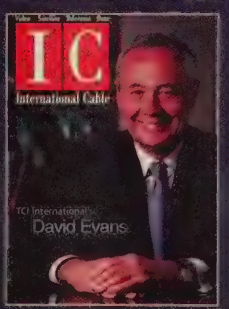

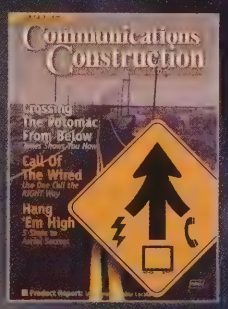

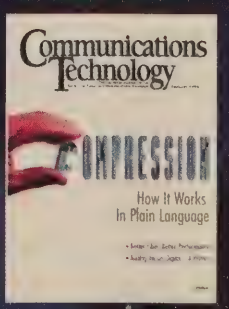

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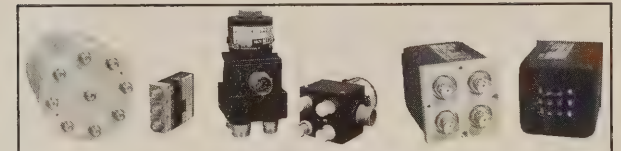

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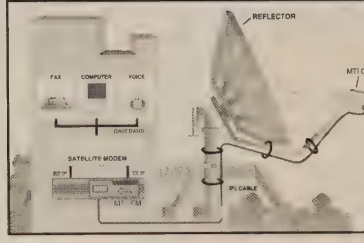

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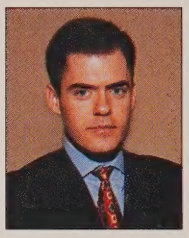
Dollars and Sense

Adversity Creates an Investment Opportunity

by Marc Crossman



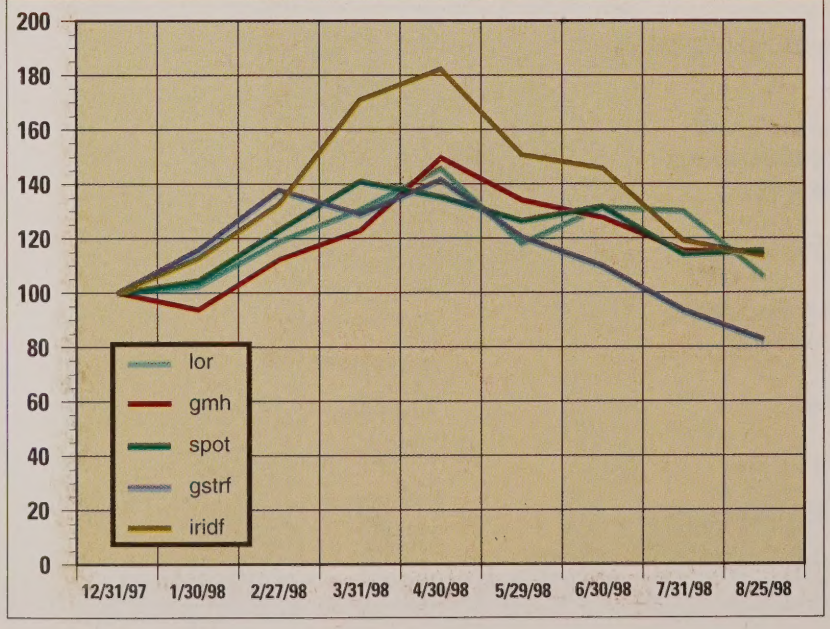
Despite a very strong start, the satellite sector seems to be suffering from a prolonged hiccup heading into the second half of 1998. Following a series of consecutive, adverse events, many satellite stocks have endured a temporary setback; however, the long-term outlook on the satellite market remains optimistic. There are some near-term catalysts that will provide some upward mobility for the entire satellite sector.

The series of near-term events that have and will continue to put downward pressures on some satellite stocks began with the China situation. A number of companies have been questioned as to whether or not they have transferred sensitive satellite technology to the Chinese through their normal everyday commercial activities. There is the possibility of a ban on sales of commercial satellites to the Chinese should a Congressional hearing determine that satellites be classified as "munitions," thereby possibly reducing the size of the addressable market. Loral Space and Communications was the hardest hit by this event, losing more than 20 percent of its value in one month. This incident appears to be lingering over the entire sector.

The next event to impact the satellite industry was in the fixed satellite segment, where Hughes discovered a problem with its HS 601 satellites that raised technical hardware questions across the sector. The first sign of a technical problem with the HS 601 was the total failure of Panamsat's Galaxy 4 on May 19, which temporarily halted service to 85 percent of the nation's pagers. This same technical failure occurred on three other HS 601s over the next three months; however, so far the impact to customers was minimal to none.

The Panamsat failure resulted in a slight devaluation of SPOT—down 14.4 percent versus three months ago; however, Panamsat's growth potential remains extensive as the company plans to launch at least an additional seven satellites in the next year and a half, expanding capacity by more than 40 percent.

Price Performance of Satellite Stocks



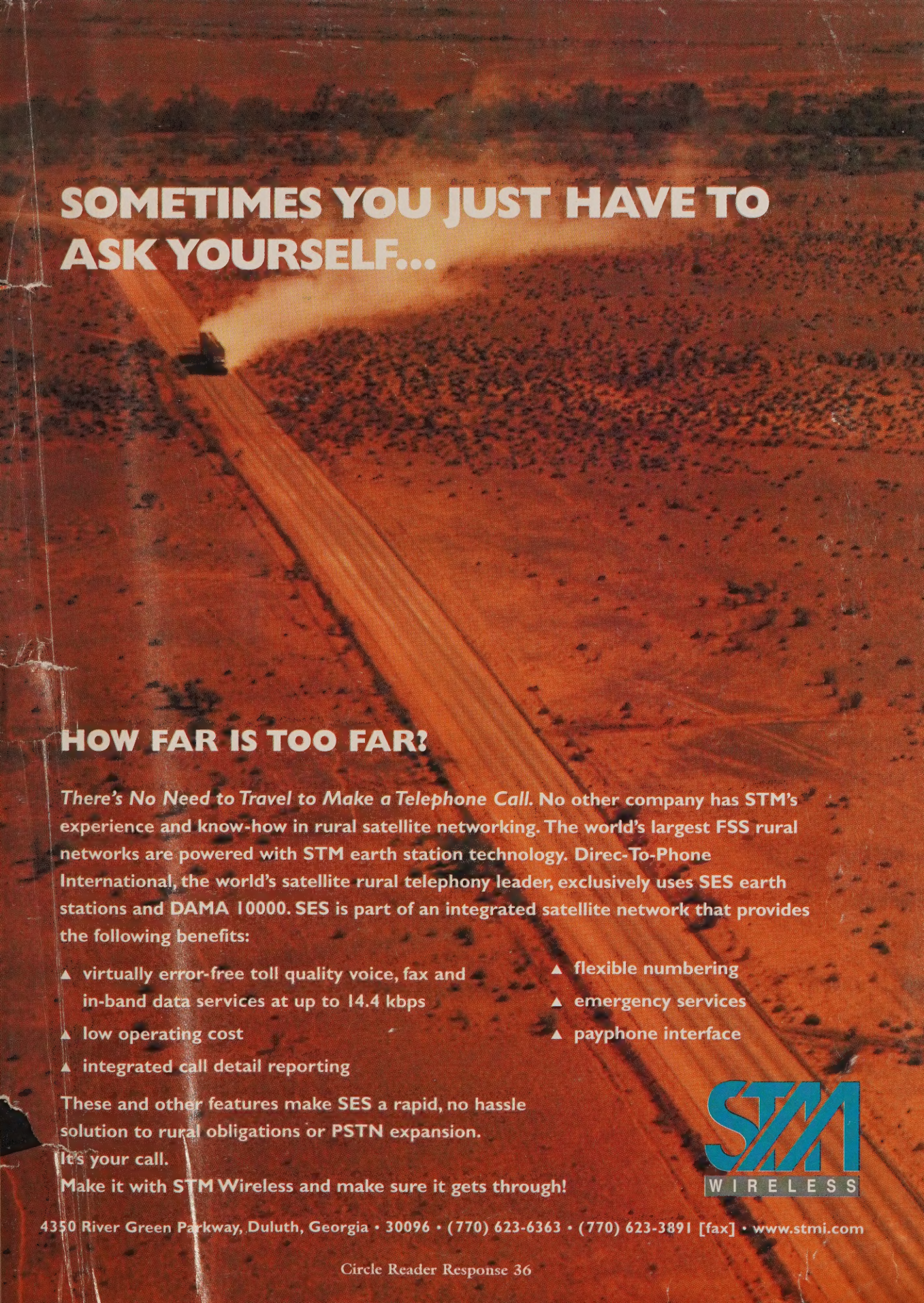
In addition, Hughes has since discovered the cause of the failures—the growth of catlike "tin whiskers," which occurs in certain tin environments resulting in circuit shortages—and deemed not systemic. The company is making arrangements to reduce to a minimum the likelihood of these episodes recurring.

In the mobile sector, Iridium's possible delay of commercial service due to software glitches and satellite losses has heightened investors' concerns. As a result, both IRIDF and GSTRF are down approximately 30 percent versus three months ago, and the IPO of ICO, the third LEO player, struggled to reach completion. Although Iridium's satellite glitches have hit the entire mobile arena, this sector is merely at the beginning of the growth cycle and holds with tremendous promise for expansion.

As well, there are positive near-term catalysts that should provide an upside to this segment: Globalstar is preparing to launch most of its 56-satellite constellation, with the next launch scheduled in September, as we went to press. These launches, if successful, should drive up shares of Globalstar.

The two key indicators that accurately define the state of the satellite arena, price and capacity, continue to reveal a strong growth outlook. In light of the recent troubles, transponder capacity and pricing in the fixed services sector remain stable, reflecting a proportionate increase in surplus and demand. Only a dramatic change in either of these two elements will cause a change in the favorable outlook. Therefore, satellite stocks are currently a bargain, especially if the new entrants, such as Iridium and Globalstar, are able to deliver on their promises of being able to generate over $4 billion in revenue by the year 2005.

Marc Crossman is a director and satellite communications analyst for CIBC Oppenheimer Corp. in New York City. These views are those of the author and do not necessarily reflect the views of the Via Satellite editors or CIBC Oppenheimer Corp.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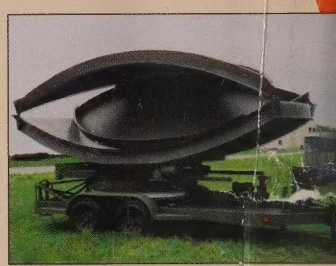

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